TWENTY-SECOND ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1929-1930

Supplement to the report of the Minister of Agriculture

Printed by order of the Legislature

THE PRINTER TO HIS MOST EXCELLENT MAJESTY THE KING

QUEBEC

1931

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1929 - 1930

To the Honourable J. L. Perron,

Minister of Agriculture,

Quebec.

Sir:—

I have the honour to present herewith the twenty-second Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the winter meeting of the Society, which was held at McGill University, Montreal on March 5th. and 6th., 1930.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

E. Melville DuPorte,

Secretary-Treasurer.

Macdonald College, Quebec.

LIST OF MEMBERS 1929-30

Armstrong, Tom	Entomological Lab. Vineland, Ont.
Adams, John	C. E. F. Dept. of Agr., Ottawa.
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de Gryse, J. J	Entomological Branch, Ottawa.
Gussow, H. T	C. E. F., Dept. of Agriculture, Ottawa.
Hale, J. D	Forest Products Laboratory, Ottawa.
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Levasseur, Rev. Paul.	Ste. Anne de la Pocatière.
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Lods, E. A.	Macdonald College.
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Maheux, G.	Provincial Entomologist, Quebec.
Major, T. G.	Tobacco Division, Dept. of Agriculture, Ottawa.
Maltais, J. B.	Hemmingford, Que.
McLennan, A. H.	Ontario Agricultural College, Guelph, Ont.
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Ménard, J. H.	Forestry School, Berthierville.
Moore, G. A.	159, Querbes Ave., Outremont.
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Piché, G. C.	Chief Forester, Quebec.
Pomerleau, René.	Ste. Anne de la Pocatière.
Reid, Peter	Chateauguay Basin, Que.
Racicot, H. N.	Division of Botany, Ottawa.
Raymond, L. C.	Macdonald College.
Raynaud, Mr	Berthierville, Que.
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Robitaille, Rev. Father	Laval University, Quebec.
Ryan, W. St. G.	379, Common St., Montreal.
Saunders, L. G.	Univ. of Sas., Saskatoon.
Savoie, F. N.	Dept. of Agriculture, Quebec.
Simard, J.	Dept. of Agriculture, Quebec.
Simmons, P. M.	Lab. of Plant Path., Saskatoon, Sask.
Southee, G. A.	356, Durocher St., Outremont.
Stevenson, J. N.	Gardenvale, Que.
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Stohr, Rev. L. M.	Ironside, Que.
Strickland, E. H.	Edmonton, Alberta.
Summerby, Prof. R.	Macdonald College.
Swaine, Dr. J. M.	Entomological Branch, Dept. of Agric., Ottawa
Tawse, W. J.	Macdonald College.
Taylor, C. F.	Wolfville, N. S.
Tessier, G.	Forest Service, Quebec.
Twinn, C. R.	Entom. Branch, Ottawa.
Vanterpool, T. C.	University of Saskatchewan.
Victorin, Rev. Bro	University of Montreal, Montreal.
Whetzel, Prof. H.	Cornell Univ. Ithaca, N. Y.

White, R. M.....Entom. Lab. Tressbank, Man.
White, A. E.....5059, Western Ave., Montreal.
Whitehead, W. E.....Macdonald College, Que.
Willey, Dr. A.....McGill University, Montreal.
Winn, A. F.....32, Springfield Ave., Westmount.

HONORARY MEMBERS

Hon. J. E. Caron, Quebec.
F. C. Harrison, D. Sc., McGill University, Montreal.
Rev. Father Superior Dom Pacome Gaboury, La Trappe, Que.
Rev. Father Superior, Ste. Anne de la Pocatière.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.
Rev. Father Leopold, D. Sc. Agr., La Trappe, Que.
Prof. Francis Lloyd M. A., F. R. S. C., McGill University.

FINANCIAL STATEMENT 1929 - 1930

MACDONALD COLLEGE, Que., Canada.

Receipts

Balance 1928–1929	107.77
Government Grant	250.00
Interest	3.89
	$ 361.66

Expenditure

Secretary's Stipend	50.00
Delegate to Canadian Phytopathological Society	20.15
Delegate to Ontario Entomological Society	45.10
Electros	30.69
Speaker at annual meeting	28.90
Expenses of annual meeting	22.19
Clerical, Postage and Printing	24.07
Balance in bank, April 30th	140.56
	$ 361.66

Audited and found correct.

GEORGES MAHEUX,
President.

J. G. COULSON,
Auditor.

E. MELVILLE DUPORTE.
Secretary-Treasurer.

ANNUAL MEETING

The twenty-second annual meeting of the Quebec Society for the Protection of Plants was held in the Biolgy Building, McGill University, on March 5th. and 6th., 1930. There were 41 members present. The programme consisted of two symposia dealing with recent advances in our knowledge of fruit and forest pests, and is included herein.

PROGRAMME

March, 5th, 2 p. m.

Symposium on recent work on Insect and Fungous Pests of Fruits.

1. The Spray Service.—S. V. Nichols, F. L. Godbout, J. G. Coulson.
2. Oil Sprays.—F. Herman.
3. Orchard Spraying.—Rev. Father Leopold.
4. Spraying and Crop Production.—R. P. Longley.
5. Role of Bees in Orchard Pollination.—C. E. Atwood.
6. Orchard Curculios and Round-headed Borers.—C. E. Petch.
7. A Newly Introduced Orchard Pest.—J. W. Cameron.
8. Summary of Work on Insect Pests.—W. H. Brittain.
9. Results of an Apple Spraying Campaign around Quebec in 1929.—Omer Caron.
10. (a) Cultural Methods in Relation to Apple Diseases in Quebec.
    (b) Raspberry Diseases and Their Control in Quebec.—H. N. Racicot.
11. Fire Blight.—J. E. Machacek.
12. (a) Relation between Weather and Ascospore Discharge, (b) Spur Blight.—G. H. Berkeley.

March, 6th, 9.30 a. m.

Symposium on Recent Work on Forest Insects.

1. Forest Insect Problems in Eastern Canada in 1929.—J. M. Swaine.
2. Some Methods in Forest Insect Investigation.—J. J. de Gryse.
3. An Investigation of *Monochamus scutellatus* and its control.—N. B. Dunn.

4. The Hemlock Looper infesting Balsam in the Province of Quebec.—E. B. Watson.
5. The Carpenter Worm.—J. B. Maltais.

On the evening of March 5th. Professor A. Brooker Klugh gave a very highly appreciated lecture on "Plant Photography". The lecture was illustrated by some of Dr. Klugh's very excellent slides in natural colours, and gave many hints on photographic technique which most of those present found very useful.

After the lecture the members attended an informal smoker in the botanical laboratory.

The business meeting was called to order by the president at 2.15 p. m., March 6th. The minutes of the last meeting were read and approved. The treasurer's report was read and accepted.

The election of officers for the two-year period 1930–32 resulted as follows:

OFFICERS FOR 1930-1932

President:—Prof. Georges Maheux, Dept. of Agriculture, Quebec.

Vice-President:—Prof. J. G. Coulson, Macdonald College, Que.

Secretary-Treasurer:—Dr. E. Melville DuPorte, Macdonald College, Que.

Assistant-Secretary:—Omer Caron Esq., Department of Agriculture, Quebec.

Directors:—Rev. Father Leopold, D. Sc. Ag., La Trappe, Que.
Dr. W. H. Brittain, Macdonald College, Que.
H. N. Racicot, Esq., Botanical Division, C. E. F., Ottawa.
Prof. E. Campagna, School of Agriculture, Ste. Anne de la Pocatière, Que.
F. L. Drayton, Esq., Botanical Division, C. E. F., Ottawa.
Rev. Father Louis Marie, Ph. O., La Trappe, Que.
A. Dustan, Esq., Entomological Branch, Ottawa.
C. E. Petch, Esq., Entomological Laboratory, Hemmingford, Que.
F. Herman, Esq., Division of Chemistry, C. E. F., Ottawa.

Auditor:—Prof. J. G. Coulson.

Delegate to the Royal Society of Canada.--The President.

Delegates to the Ont. Ent. Society:--Rev. Father Leopold, Dr. E. Melville DuPorte, Dr. W. H. Brittain.

It was decided to hold the next meeting at Macdonald College.

Messrs. J. B. Maltais and A. E. White were proposed as members and elected.

On the motion of Professors Maheux and Brittain, Professor Francis E. Lloyd of McGill University was elected to honorary membership in recognition of his valuable contributions in the field of plant physiology.

The meeting discussed the question, raised by Prof. Maheux, as to the advisability of charging a small membership fee. It was decided to give the executive committee discretionary powers to levy this fee should they deem it necessary to do so.

The following resolution was put to the meeting and carried unanimously:

Be it resolved that this society tenders to Prof. F. E. Lloyd its sincere thanks for his courtesy in granting the use of the Biological Building for the meetings of the society, and for his kindness in attending to so many of the details that have helped to make the meetings a success.

NOTES ON SOME ESSENTIALS IN THE OPERATION OF A SPRAY SERVICE FOR APPLE SCAB CONTROL

By J. G. Coulson, Macdonald College.

In Canada and the United States spray service recommendations for the early sprays for the control of apple scab are based upon the fact that the fungus overwinters in the old dead infected leaves. However, there is evidence that in many cases considerable and important infections may arise from overwintered mycelium in twig infections or possibly conidiospores. In England the primary infection has long been considered to be established each spring by conidia from the diseased twigs and only quite recently has the perfect stage been found and considered to be of importance.

Morse and Darrow 1913 have given evidence that the overwintered conidiospores on the diseased twigs were a source of infection in the spring in Maine and elsewhere and secured viable conidia up until about the 1st of May, when the leaf buds were beginning to open.

Morris in 1914 reported infected twigs in Montana yielded living cultures as late as March.

Fraser in 1917 found twig infection bad on McIntosh in Quebec. He could not obtain living conidia from a few of these twigs in the spring, but was able to find freshly produced spores on infected McIntosh twigs from Nova Scotia. Twig infection on McIntosh and Fameuse has been reported as producing primary infections in both Nova Scotia and New Brunswick.

Fraser reports viable conidia (5-10 per cent) from infected apples lying under the snow in the early spring.

Folsom 1926-1928 has made a study of this problem in Maine and finds that considerable primary infection may originate from diseased twigs by means of newly produced conidia. The pustules may not produce conidia until well on in the spring or summer and infection from this source may occur even after July 1st and during or after ascospore infection. This infection often originates even in spite of the spraying of twigs and leaves. Pruning seems quite effective. The diseased twigs are often killed or become infected with black rot canker.

In Ohio there is some indication that conidia may live through the winter on the diseased leaves.

In Wisconsin conidia overwintered on leaves stored outside under dry conditions. Perhaps this would not occur in the case of a leaf on the ground exposed

to wetter conditions. Thus it seems that the overwintering of the fungus by means of conidia or mycelium in the twigs needs further study.

However, ascospores undoubtedly seem to be the most important agents of primary infection and a knowledge of their production and of factors conditioning infection by them is of extreme importance. This does not debar the possibility of conidia being important or even the most important cause of primary infection under certain circumstances.

Microscopic examination of leaves and spore trap studies carried on for the past 8 or 10 years in various parts of Canada and the United States has revealed the fact that great variations occur from year to year in the dates of maturation of spores and first discharges from the leaves. There is also extreme variation between the time of first ascospore discharge and tree development. Thus in one season the first discharge may occur long before the bloom period and in another even after this time. It has been found, however, in rearly all regions that the pink, calyx and 10 day spray are of great importance as spores are usually present at this time and under conditions suitable for establishing infections. The first discharge varies from district to district or with orchards in the same districts, with the valley and the upland and variety. Crab, McIntosh and Fameuse produce mature ascospores earlier than many other varieties.

According to Wilson ascospores develop most rapidly at about 18°C in old leaves which are continuously or intermittantly wet enough to be friable, but not at all in dry leaves. He thinks that the infected leaves which fall from the tree early tend to produce mature spores earlier than those falling later. Hockey does not quite agree with this and states that temperature and moisture have more influence than time of leaf fall.

Ascospores once they have become mature are discharged freely at any temperature above freezing when the leaves are thoroughly wetted for a few hours. I have caught on a slide hundreds of ascospores discharged from a single leaf which was dry and brittle when collected, after wetting it and placing it in a moist chamber, in four hours time. Discharge commenced in some cases in less than an hour after wetting.

From 4-20 hours of wet leaf surface depending upon temperature are required to establish infection by spores placed on leaves. Intermittant wetting for longer periods may lead to heavy infections. Thus a day or two of wet weather constitutes a danger period since this provides sufficient moisture and time for spore discharge, spreading of spores in orchard, and infection. Many have found heavy dew or slight showers sufficient to give slight or heavy discharges, and Folsom states that primary infections were established in Maine when no rainy period (2 days) had occurred. Theoretically heavy dews or slight showers should provide sufficient moisture for infection.

Thus only in a broad way are the conditions influencing ascospore production, discharge and infection known. One cannot predict when these events will occur and so this demands a microscopic examination of leaves with respect to ascospore development and discharge. The real problem presented is how to enable the grower to produce the most satisfactory control of scab. This does not necessarily mean the most effective control as other things such as costs, injury, etc., must be considered. Reducing the scab by any practice by one to even ten per cent is a doubtful paying proposition.

The problem can be adequately or otherwise met in one of three ways: (1) apply sprays each year that will control scab in the worst years, (2) follow the spray calendar which gives good average results and (3) vary the programme according to the seasonal conditions.

During the last few years many studies of asospore discharges have been carried out in various districts with the hope that this knowledge would be an aid in timing early sprays. It seemed that with this knowledge and a weather prediction the proper times for spraying could be foretold. However, the difficulties in the actual working out of this are very great. In the first place our knowledge of the behaviour of the fungus under various conditions is not sufficiently accurate and secondly weather predicting is not sufficiently reliable and specific enough for most districts. The prediction should not only indicate rain but also its duration. Showers and dews are predictable with difficulty in many cases.

The great variation in the development of the fungus noted above makes it extremely difficult to select average or representative leaves for the orchard or district to be used in spore traps. Then it is impossible to estimate what a certain rate of discharge from a few leaves means for the whole orchard or district. A further difficulty is presented by the fact that while a heavy discharge in the orchard is likely to be most serious yet the nature of the season may reduce the possible effect of a heavy discharge and enhance the effect of a light one and all of this is not any too well understood.

In most cases it has been found that a study of ascospore development and discharges together with a daily weather prediction does not constitute an absolute basis for the making of spray recommendations. In Delaware, Virginia and Maine it has been quite inadequate while in Ohio the method seems to work very well but a considerable number of investigators are required to carry it out for the state. Personally I am convinced it is of value to one running a spray service in making recommendations for the first application. Then again ascospore production should be followed to completion in order to determine the time at which it is safe to ease up in the spraying of an orchard in which primary infection has been prevented.

Spray service organizations, have proven of value in practically all cases. It must be admitted that the chief benefit has come from the spreading of information among the growers with the giving of advice largely of a general nature rather than to the expert being able to manipulate the spray programme according to his microscopic study or knowledge of the apple scab fungus. One who understands as well as can be done the principles of spraying, the behaviour of the fungus and its development in any season, and combines with this good judgment, can do a great deal to fit the spray programme to the season. The development of the host is, of course, also an important consideration in this respect.

Reports on spray service work have been very faulty because of the appalling lack of any check plots in orchards where one of each of the recommended sprays were omitted. The spray service programme should also be checked against the regular spray calendar for that district.

A survey of about 150 orchards in Quebec was made last fall relative to scab control. This proved to be quite unsatisfactory because of lack of accurate information relative to their orchards on the part of the growers. Also variations in number of applications, pressure, concentration, and amount of spray used, size of machine, etc., made possible only the most general conclusions. Progress in this respect can apparently best be made by establishing controlled experimental orchards in each district together with the anyalsis of accurate records kept by growers on equipment, applications, etc., for each of these districts. This latter involves a good deal of educational work to be done among the Quebec growers.

An important problem in Quebec is the development of late fruit infections and storage scab. Folsom in Maine has found that storage or pin head scab can be caused by a late infection on the fruit which may not be evident at time of picking, but which develops later in storage. This storage scab may be prevented by the application of an August spray, but it may also be established even before August and so this spray may not reduce it. It is to be noted as well that differences of opinion exist as to whether scab spreads in storage from apple to apple and this point needs further study. The possible disadvantages of a late spray application just previous to picking are well known.

We feel that a late spray application may prove beneficial because of its possible effect in reducing the number of perithecia in the orchard the following spring. We found the highest percentage of leaves showing perithecia in orchards which the previous year gave rise to storage scab. Also the perithecia in such cases were more commonly found on leaves showing no scab spots. The natural conclusion seems to be that the leaves showing no spots were infected late along with the fruit. The fruit developed visible scab in storage and the leaves perithecia in the spring. A late spray then would have reduced both.

A late leaf infection of this type may possibly explain the difference of opinion that exists concerning the spread of the fungus through the dead fallen leaves. Wilson in Wisconsin reports that, the fungus spreads very little from the margin of the old spot. Folsom found 19 per cent of the scabby leaves had developed scab and only 3 per cent of the apparently healthy leaves. Jehle and Hunter in Maryland found perithecia developed on practically all dead leaves on which there was a very low percentage of infection the previous year. This seems to indicate spreading in the leaf and from leaf to leaf.

I believe that much of value cold be obtained by the establishment of experimental orchards in Quebec where various materials, rates of application and variations and spray programmes could be tested. The importance of twig infection should be investigated. The possibility of conidia overwintering should be studied. The value of a late spray application in controlling storage scab and its possible effect in reducing the number of perithecia the following spring seem worthy of determining.

Folsom found that ascospores were not reduced by late spraying (October) of the leaves with copper sulphate. In agreement with our contention an earlier spray might have been of more value. Salmon and Ware in England found the perithecia scattered over the whole surface of the leaf irrespective of the distribution of the scab spots of the previous year. Keitt reports reduction in perithecial production by spraying trees in the fall with arsenites.

Crutis in N. Z. claimed to have reduced perithecia production by spraying the dead fallen leaves.

Thus it is seen there are a number of problems and details fundamental in the controlling of apple scab the solution of which would be of much value in the improvement of our spray methods and programme.

SPRAY CIRCLES IN THE ANNAPOLIS VALLEY

by S. V. Nichols

The organization of spray circles as a means to assist the apple growers with their problems in the Annapolis Valley is a comparatively new feature and marks the development of a promising line of work in the field of economic entomology.

For a number of years previous to the organization of the spray circles there developed a growing demand on the part of the growers for advice and assistance in connection with their spraying problems. The Wolfville district being the seat of the Provincial Entomological Laboratory was better served in this respect than elsewhere, with the result that other sections began to call for similar service. The attempt to carry on the work without definite organization resulted in many duplications and waste effort and it was soon realized that a more efficient system was necessary.

The first step in this direction was the establishment of "Spray Service Bulletins". The laboratories of Plant Pathology, Kentville, the Dominion E tomological Laboratory, Annapolis Royal, and the Provincial Entomological Laboratory, Wolfville, cooperated in supplying timely spray notes to the secretary of the Nova Scotia Fruit Growers Association, who arranged for their publication in the daily press. These bulletins consisted chiefly of warnings of the approach of critical periods and the control of certain specific pests such as apple scab, green apple bug, etc. These bulletins are still a feature of the spray circle and undoubtedly serve a very useful purpose.

The demand for more personal attention to enable the grower to deal with his special problems, to assist him in the recognition of the particular pests that infect his orchard and to advise him regarding their treatment, continued to increase. The policy of forming definite spray circles was first placed before the growers by Dr. W. H. Brittain in a series of orchard meetings in 1927 held under the auspices of the Nova Scotia Fruit Growers Association. An essential part of the proposal was that the Nova Scotia Fruit Growers Association furnish the fundamental requisites. No immediate action was, however, taken by the association but, nevertheless, the growers of two districts organized themselves the following winter. So successfully did the scheme work that 14 new "circles" were organized the following winter of 1928 by C. A. Good, secretary of the Nova Scotia Fruit Growers Association, making in all 16 "circles" with a total membership of 486. The new circles were later put on a working basis under the capable direction of the newly appointed Provincial Entomologist, A.D. Pickett, who now is the head of the spray circle work.

As finally established the spray circles have the following organization.

1. Each circle functions as a local branch of the Nova Scotia Fruit Growers Association. The system adopted is simplified as much as possible to ade-

quately meet the general requirements. Each circle appoints a secretary-treasurer, president, vice-president and as many "key-men" as are considered necessary to cover the different sections of the district served by one circle. The secretary assumes the role of general correspondent, whose most important function is to receive and distribute timely bulletins and information sent to him by telephone or wire from the technical advisors. The secretary distributes the information to the key-men, who, in turn, notify each individual member in his alotted district.

2. The technical advisors consist of A. Kelsall, head of the Dominion Entomological Laboratory, Annapolis Royal, J. F. Hockey, head of the Plant Pathology Laboratory, Kentville Experimental Farm and A. D. Pickett, Provincial Entomologist, head of the Entomological Laboratory, Wolfville. These department work in unison in issuing the information bulletins which are sent to the spray service specialist, "circle" secretaries and also to the press so that as large a number as possible may come in contact with the information.

3. The spray service specialists are under the direction of the Provincial Entomologist. Each specialist is given charge of a territory including several circles. The Provincial Entomologist takes charge of one territory in addition to the general investigation work.

The duties of the spray circle specialist are: (1) to act as liaison officer between the technical advisors and the members, (2) to conduct demonstrations and meetings when considered advisable, (3) to make personal visits when required, (4) to make pest survey for the individual grower and (5) to keep constant watch and report outbreaks of insects and diseases.

The pest survey is made in late summer and autumn, when the fruit is sufficiently large to differentiate easily the work of the various insects. A complete survey is made of the orchards and the degree of infestation of each insect charted on a form against the varieties infested. The recommendations for the next season are tabulated on the back of the sheet. Each member receives a chart of the conditions noted in his orchard and a copy is retained in the office for future reference and record.

The spray specialist is a much sought after man during the active spraying season and finds it necessary to allot each day to a certain definite locality. If considered desirable an orchard meeting may be held in an orchard known to harbour certain pests or where actual specimens of insects or their work may be examined and individual visits may be carried out as far as time permits. Since many growers are at present not fully acquainted with the various orchard pests or their work in early stages, this work forms a valuable educational feature of the circles which are designed to make the growers increasingly independent of outside advice and more capable of dealing with their own problems. It is hoped ultimately that we will be able to reduce the service in the older "circles" and offer the same service in new territory.

PETROLEUM OIL, SOURCE AND METHOD OF USING AS AN INSECTICIDE

By Frank A. Herman, Division of Chemistry, C. E. F., Ottawa.

Introduction

The early white settlers on the American continent became acquainted with petroleum first of all through the Indians who had known of its curative properties from time immemorial, and for more than a century it was called "Seneca Oil". During many years the oil was collected by soaking flannel rags with the oil scum which formed on the surface of swamps and ponds, and wringing them out. The oil obtained in this way was sold by vendors as an antidote for certain maladies.

In 1830 the presence of oil was noticed in the swamps of Enniskillen township, Lambton county. The first well for the purpose of obtaining and refining oil on the North American Continent was "dug" at Oil Springs, Ontario, in the year 1858 (a) by J. H. Williams of Hamilton. The depth of this well was about 100 feet. Oil of a lubricating quality was obtained in a gravel bed on top of the limestone. About ten such wells were dug in all. This was really the first oil well in America, although it did not pierce the limestone. The discovery of oil by "drilling" which was made by Colonel Drake near Titusville, Pennsylvania in 1859 began a new era in the history of petroleum. While Canada possesses the distinction of having the first "dug" well for petroleum on the North American continent, the honour of tapping the source of it by "drilling" goes to the United States.

The distillation of oil from shale is the work of a Scotsman, James Young. In 1850 Young took out a patent for the production of paraffin by distillation, and this marks the beginning of the exceedingly complex industry which is conducted in our modern refineries.

The Refining of Petroleum

When crude petroleum is not directly employed for fuel it undergoes a process of fractional distillation in a refinery, whereby various products, or distillates are obtained which meet trade requirements by falling within certain ranges of boiling point and specific gravity. There is considerable overlapping and confusion in the nomenclature of these various commercial products, caused partly by the fact that crude oils from different regions yield different sets of products and in various proportions.

Refining may be partial, the lighter fractions only being taken off and the whole of the residue used as fuel, or the process of distillation may be continued,

(a) Thirty-second Annual Report of the Ontario Department of Mines. p. 76.

and gas oil, lubricating oils and paraffin wax also be obtained. Owing to the difference of refinery practice and the varying qualities of crude oils, it is impossible to draw up a list of products which is of general application but the following will give some indication of the characteristics of the various products.

—	Boiling Point (°C)	Specific Gravity
Petroleum spirit (gasoline, petrol, naphta, etc.)	Up to 200°C.	0.650 to 0.750.
Burning oil kerosene or "paraffin"	150° to 300°	0.800 to 0.825.
Solar or gas oil	250° to 340°	0.865.
Lubricating oils	340° to 500°	0.900 to 0.950.
Fuel oils	Above 300°	0.900 to 0.960.

Not only do the distillates vary to some extent in nature and yield with the character of the crude oil, but a certain variation can be induced by modifying the manner in which the distillation is carried out. The points of distillation of different products change with the demand.

Various grades of oil are often blended to improve the distillation range. Lubricants are blended for viscosities, colours and other qualities. Rarely is a finished lubricant a straight run product. In addition to the various refinery stocks, other oils, such as rape seed oil and lard oil, are blended with the mineral oils. Later work recommends the addition of a topped mineral oil instead of rape seed oil for compounding.

Characteristics of Crude Oils

Petroleum is not a definite chemical compound. It is an extremely complex mixture of a series of hydrocarbons, chiefly of the paraffin, benzene and naphthene series, and while the hydrocarbons are the chief and most important group there are also present small amounts of other chemical compounds containing nitrogen, oxygen and sulphur— these usually exist as derivatives of the hydrocarbons and are to be regarded as impurities. Hydrogen sulphide, water and earthy matter are often present— all varying according to the district in which the oil is found. In appearance, oil varies in colour from water white, through amber, to brown and black— the black being the most common. The smell of some oils is pleasant, others have a decidedly disagreeable odour.

One of the most important properties of petroleum is its volatility. The lighter products escape when exposed to the air, in the form of vapor or gas, and the residue gradually becomes denser and denser, until it reaches a solid state, when it may form a natural asphalt road, as may be seen in the interior of Mexico. Upon the volatility of oil depends the whole process of refining, the purpose of which is to separate the oil into its many valuable products. From the viewpoint of the petroleum refiner, crude petroleum is of two general classes

or types, viz. those petroleums which carry little or no asphalt and which are termed "paraffin-base", and those which yield practically no solid paraffin but are rich in asphalt and are called "asphalt-base" petroleums. Strictly speaking however, there is still another class known as "paraffin-asphalt, semi-asphalt or mixed base" petroleums, typified by certain of the crude oils from the mid-west American fields which contain both paraffin and asphalt and are therefore a combination of the two other classes. Oils are frequently referred to as "light" or "heavy", the lighter oils having a paraffin base and the heavier oils and asphalt base.

A few typical examples of yields of oils from representative fields are submitted.

Pennsylvania: 42° Be. Gravity

(*Yields by complete process*)

—	Per Cent	—	Per Cent
Gasoline	28	Non-viscous neutral	6
Turpentine substitute	12	Viscous neutral	4
Kerosene	15	Cylinder stocks	15
Mineral seal oil	3	Wax	2
Gas & Fuel Oil	10	Loss	5

Mid-continent: Average Pipe Line Run

(*Yields by Complete process*)

—	Per Cent	—	Per Cent
Gasoline	23	Viscous lubricants	6
Kerosene	15	Fuel oil	16
Engine distillate	5	Wax	1
Gas Oil	25	Loss	5
Non viscous lubricants	4		

These yields can be taken only as characteristic, and are subject to some variation, since it should be noted that the results obtained in refining will depend upon the method of running, and that the number of methods of running or of combinations of such methods is very great.

Emulsions

The value of mineral oil as an insecticide has long been known, particularly that of kerosene, which for a long time occupied an important place in spraying practice. Kerosene is one of the lighter fractions of petroleum oil (.780-.820 sp. gr.) but has been found to be too light and volatile to be satisfactory as a scalicide. More recently heavy petroleum fractions and refined oil have been found of great value both as a winter and summer spray. In cheapness and effectiveness they are much superior to kerosene; unfortunately though, they are at the same time more toxic to the plant. Kerosene itself occasionally causes injury to foliage but heavy oils in general, and unrefined distilates in particular, have occasionally caused most disastrous effects on fruit trees, even when used as a winter spray. Continued experimental efforts finally led to a fairly successful method of using petroleum oils, first in the form of mechanical mixtures, then as miscible or soluble oils and oil emulsions.

An emulsion* is a system containing two liquid phases, one of which is dispersed as globules in the other. The liquid which is broken up into globules is termed the dispersed phase, whilst the liquid surrounding the globules is known as the continuous phase or dispersing medium. The two liquids, which must be immiscible or nearly so, are frequently referred to as the internal and external phases, respectively.

For two given liquids, such as oil and water, at least two sets of emulsions are theoretically possible, depending upon whether the oil is dispersed in the water, giving an oil-in-water type of emulsion, or *vice versa*, giving a water-in-oil type of emulsion. Also it is quite possible that emulsions of a desired concentration can be made of either liquid in the other.

Emulsions of the oil-in-water type, the prevailing type of emulsions used in insecticidal work are usually white or pale yellow in colour. The more concentrated the oil phase, the more pronounced becomes the white or creamy colour.

In the early periods of oil-spray experimentation we had still another type of emulsion, the mechanical emulsion or mechanical mixture, in the preparation of which the types of spray machines used all operated to break up the oil into fine particles and keep its suspended in water by a high degree of agitation. As this type of "emulsion" separates almost immediately, lack of perfect agitation often resulted in "naked" oil being sprayed on the tree, with consequent serious injury.

Miscible Oils.—In a "miscible" or "soluble" oil the emulsifier is soluble in the oil—an oil solution of an emulsifier—with little or no water present, and contains from 85 to 90 per cent of oil. The miscible oils spread and wet well, and are effective against hiding pests, unarmored scales and eggs. They do not spoil from freezing nor settle on standing but require care in diluting. They should never be thrown into a tank full or partly full of water, but the water should be

* The Theory of Emulsions and Emulsification.—W. Clayton.

added gradually with thorough agitation until the creamy stage is reached when the balance of the water may be rapidly added. Some proprietary miscible oils are Scalecide, Scaleproof, Spramulsion, Sunoco, Calox, Keresol, Carbokrimp, Dendrol, Mortegg and Jeyes' Fluid while Dormant Soluble and Dormoil, which are generally regarded as miscible oils, are on the border between a true miscible oil and an emulsion stock.

Emulsion stocks are concentrated emulsions of oil, emulsifier and water containing approximately 75 per cent of oil and lend themselves more readily to dilution with water than do miscible oils. Because the emulsion stocks contain considerable water, freezing ruins them and some forms are liable to settle, hence require thorough shaking to effect homogeneity before using. They can be measured into the spray tank at anytime when it is being filled, with agitator running, which is usually sufficient to bring about a uniform spray emulsion.

Stable and Quick Breaking Emulsions.—Emulsions of this character are governed largely by the type and quantity of emulsifier employed in effecting emulsification. In the "stable" type of emulsion the oil is more firmly bound up with the water so that when the emulsion is sprayed on the tree and insect, the oil is not available as an insecticide until the water has evaporated. It is the only safe type of emulsion to use when using oils quite high in sulphonated oils.

The "quick breaking" type of emulsion has been devised for summer sprays. In this case it is essential to use oils that will not damage trees, fruit or foliage—the oil should be highly refined. When the spray emulsion is applied, it breaks immediately on strking the tree so that the run-off is water and emulsifier and the oil remains behind to coat the tree, leaf and insect. This type of emulsion is very effective and utilizes the oil to a greater advantage.

Specifications

This is a subject I wish to discuss with some diffidence owing to limited actual experience with oil specifications and the anomalies arising from a perusal of the literature of specifications recommended by different workers. It does appear that specifications in many cases have been suggested by various experimenters without any concrete idea of what insect, egg or scale they wished to control. The following information, however, is being submitted for your consideration. It has been recommended that for black or citricola scale on citrus trees a summer spray oil of viscosity (at 100° F.)—70-80 be used; for red, purple or yellow scale, a heavier oil. For eggs of the leaf roller, a medium to light oil; for eggs of the red spider a heavy commercial oil applied during the dormant season. The control here seems to be due to smothering, a condition which is not attained by the use of a lighter oil. An oil should have insecticidal value and decision as to the use of it should only be arrived at after suitable testing. An oil before use should be tested, the specifications of viscosity, unsulphonated residue and volatility confirmed and in this way the selection and use of spray oils may be placed on a more exact basis.

Petroleum Glossary

Asphalt: A neutral solid, or viscous mixture of partially oxidized hydrocarbons. Usually dark brown or black in color, melts at 90° to 100° F. and is to a large extent soluble in oil of turpentine, ether or alcohol. Occurs as seeps, springs, lakes and as impregnations in rocks. Manufactured asphalt has a melting point of 130° to 180° F., and is an unoxidized product, free from impurities found in natural asphalt.

Asphalt Base Petroleum:—Asphalt base petroleums are those which yield an asphalt residue on evaporation or distillation.

Paraffin Base Petroleum:—Paraffin base petroleums are those which yield a paraffin residue on evaporation or distillation.

Semi-Asphaltic Base Petroleum:—Semi-asphaltic petroleums are petroleums containing a semi-asphaltic base, i.e. petroleums whose residues produced by evaporation or distillation while composed mainly of asphaltic hydrocarbons, contain also a certain percentage of paraffin wax.

Body.—The fluidity of a lubricating oil or other liquid; also the measure of total fluidity expressed in the number of seconds in which a given quantity of the oil at a given temperature flows through an aperture (viscosity).

Benzine:—A colorless, inflammable and volatile liquid obtained from petroleum by fractional distillation, and consisting of various hydrocarbons. Called also petroleum spirit.

Benzine-Naphtha:—A naphtha having a gravity of 70° Baume. It is made by treating and redistilling crude naphtha of the gravity of 68° to 80° Baume.

Naphtha:—This term, which was formerly applied to any fluid and volatile variety of bitumen, is now generally held to include all those petroleum fractions which boil below 280° F; but this limit is not observed by all refiners and consequently commercial naphthas may present wide variations. In the valuation of naphtha, stress is laid on a mild odor and a water-white color.

The term naphtha also applied to the less volatile portion obtained on redistilling benzine and boiling from about 95°-120°C. The term is unfortunately very loosely used, and is synonymous with "mineral naphtha". The best practice is to confine the designation "naphtha". to mixtures of light hydrocarbons intended for some purpose that requires a very good odor, such as dry-cleaning, varnish-making, soap-making etc.

Mineral Oil-Naphtha:—A limpid or yellowish liquid, lighter than water, and consisting of hydrocarbons. Petroleum is heavier than naphtha, and dark greenish in color when crude. Both exude from the rocks: but naphtha can be distilled from petroleum.

Cracking of Oil:—A name given to the method by which hydrocarbons of one composition are reduced to lower members of the same series, or converted

into other hydrocarbons during distillation. It means just what its connotation conveys, namely, a part alteration, as distinguished from the more complete decomposition which would disrupt the molecule largely into carbon and gas. Cracking simply alters the molecules to an extent that produces an amount of low boiling fractions that cannot be obtained by simple distillation.

Distillate:—The product of distillation, a petroleum distillate.

Gasoline:—A name applied broadly to the lighter products derived from the distillation of crude petroleum having a range of boiling point with a final up to 450°F. It is volatile, inflammable, used as a fuel in vapor form; also as a solvent for fats and oils.

Go-Devil:—A scraper with self-adjusting spring blades, inserted in a pipe line and carried forward by the fluid pressure, clearing away accumulations from the walls of the pipe. The term is also applied to the device for exploding the nitro-glycerine used to shoot an oil well.

Hydrocarbons:—Compounds of the elements hydrogen and carbon, in either solid, liquid or gaseous form. Natural gas and petroleum are mixtures of hydrocarbons. There is practically an unlimited number of such compounds which vary greatly in physical and chemical characteristics. Complex mixtures of hydrocarbons constitute by far the greater proportion of all bitumens.

Petroleum:—In its widest sense the term petroleum embraces the whole of the hydrocarbons—gaseous, liquid and solid—occurring in nature. The word petroleum in general use signifies an oily, inflammable, liquid mixture of numerous hydrocarbons, chiefly of the paraffin series, occurring naturally, oozing from crevices in rocks, floating on the surface of water, or in subterranean deposits in rocks, from which it may be obtained by boring. The petroleums found in different areas vary widely in composition and appearence.

In general, there are three kinds of petroleum, namely, paraffin-base, which covers solid paraffin, hydrocarbons and little or no asphalt; asphalt-base, which contains asphalt and practically no paraffin, and paraffin-asphalt, a combination of the two. Petroleum is also known as rock oil, mineral oil, natural oil, coal oil, seneca oil.

Petroleum Ether.—Some refiners have applied the designation to a product, ranging in specific gravity from 0.590 to 0.666, that is cymogene, rhigolene and gasoline. Russian petroleum ether varies in specific gravity from 0.650 to 0.660 at 15°C.

Petroleum Naphtha.—A term which is loosely employed; it often denotes the first fraction obtained in distillation of crude oil, but is also applied to any low-boiling petroleum product.

Petroleum Spirit:—A term which is variously used, but is sometimes applied to a petroleum distillate of a density of 0.71 to 0.74 and a boiling point of 0.679 to 0.745.

Refining.—The manufacture of petroleum products by a process of distillation from crude petroleum, in which successive components are vaporized and separately condensed. The resultant distillates are then redistilled or chemically purified to yield the finished products of commerce.

Viscosity.—The property of an oil that determines its rate of flow and is closely related to its internal friction; it is a measure of the degree of its fluidity. The measure of fluidity is the time in seconds required for a given volume at 60°F. or 100°F., to flow through a given aperture.

Oils

Aeroplane Oil.—A white, straight-reduced viscous neutral oil.

Burning Oil.—A common name for kerosene.

Carbon Oil.—A trade name for kerosene.

Coal Oil.—The crude oil obtained by the distillation of bituminous coal. That distillate obtained from such a crude oil which is used for illuminating purposes—formerly used for the product now known as kerosene.

Kerosene.—A mixture of hydrocarbons whose average boiling point is about 450°F, freed on the one hand from gasoline or naphtha and on the other hand from the heavy hydrocarbons that belong to gas oil and lubricating oil.

Crude.—A name for crude petroleum.

Crude Mineral Oil.—A name for crude petroleum.

Crude Naphtha.—Unrefined petroleum naphtha.

Dust Laying Oils.—Crude oils, heavy asphalt oils, tars, solutions of petroleum asphalt in gas oil, liquid asphalt, and emulsions of oils and water, used for laying dust on roads.

Fuel Oil.—Any product of petroleum used for the production of power or heat. Fuel oils from mid-continent petroleum range from at least the distillate series, down to and including any product which can be made liquid by steam heat and for which no better market outlet can be obtained.

Polishing Oil.—A term applied to that fraction having a boiling point of 130 to 160°C, obtained in refining petroleum.

Rock Oil.—A synonym for petroleum.

White Oil.—An odorless and colorless oil possessing a specific gravity of 0.857. It is used medicinally, as a base for creams, salves and ointments, and as a summer spray oil. Found on the market under the trade names of Nujol, Petrolax, Paroline, Petrolol, etc.

AN ECONOMIC STUDY OF SPRAYING AND THE APPLE CROP

R. P. Longley.

I have been asked to speak to you on one aspect of the economic survey on which I was working the past summer. This survey was conducted in the Annapolis-Cornwallis Valley, Nova Scotia. The work was done, under the direction of Dr. W. H. Brittain, in connection with the Orchard Pollination Investigation, conducted by the Federal Department of Agriculture.

The following discussion deals with one of the important factors influencing the yield of apples. viz., the application of sprays and dusts. This study includes data from 96 growers. These were arranged into five fairly distinct groups from the standpoint of location. The soil types represented by the five divisions were fairly distinct. The selection of districts and orchards was made with a view to obtaining a random sample of the growers of the Valley, but an examination of the data shows that we were not entirely successful in this, since both the orchard acreage per farm and the yield per acre are above the average for the Valley according to the most reliable statistical figures. The selection is believed to be sufficiently large and representative, however, to give reasonably accurate results. In the year of the survey the orchards studied produced 102,620 barrels of apples from 1824 acres of bearing orchard, this is practically 10 per cent of the crop of the province for that year. The weighed average yield for that year on these orchards was 56.3 barrels per acre. (The standard deviation of the average yields of the individual orchards is 24.6 barrels around this average for the whole.) The range of the average production for the different farms was from 8 to 118.1 barrels.

The factors which were found to influence the yields of the orchards were: (1) the amount of commercial nitrogenous fertilizer; (2) the degree of specilization of the farms, as measured by the percentage of gross receipts obtained from apples; and (3) the amount of spray and dust material applied, as measured by the cost per acre of orchard.

The cost of spray material is an important item in this fruit-growing district. The total expenditure, of the 96 growers, for spray and dust material amounted to $20,880.38 for the crop of 1928, an average for each grower of $217.50, or $11.45 per acre of bearing orchard, or 20.34 cents per barrel. There was a range from $1.56 to $22.50 in the acre costs and from $8.33 cents to 60 cents in the barrel cost for spray and dust materials. It is the relation between the spray costs per acre and the crop produced that forms the basis for this discussion. The following table from a cross-tabulation reveals this most plainly.

The growers are classified according to the amount spent for spray materials per acre of bearing orchard, and the average yield for each group is given.

Cost of Spray	Number in Class	Average Production of Orchards Falling into those Classes
$ 2	1	16.2
$ 2.01 — $ 4	4	21.8
$ 4.01 — $ 6	2	42.2
$ 6.01 — $ 8	19	52.2
$ 8.01 — $10	22	55.8
$10.01 — $12	9	57.7
$12.01 — $14	12	68.7
$14.01 — $16	6	57.9
$16.01 — $18	11	62.8
$18.01 — $20	8	76.2
$20.01 — $22	1	46.3
$22.01 — $24	1	85.0

These results show conclusively the upward trend of crops as the amount of spray is increased. The irregularities that exist would be somewhat smoothed out if data from a larger number were available. A similar conclusion was drawn as a result of the determination of the coefficient of correlation between the crop and the cost of spray material, which was found to be 0.394 ± 0.058; this though not large is considered significant. Obviously the increased spray was not the only factor entering into the increase in crop. There is no doubt that there was a general improvement in the care of the orchard and in the amount of fertilizer applied as the spray costs were increased. In other words, high spray costs were associated to some extent, with large applications of fertilizers and improved care of the orchards.

There is a limit beyond which increased spray costs will not influence yields. The figures in the cross-tabulation, I believe, indicate this. A study of the individual districts is also significant in this connection. One of the districts showed considerably higher yields than the others. It also showed the highest cost of spray material per acre. In this district the range in spray costs was from $7.14 to $18.82, with a mean of $13.70 per acre. The range in production per acre was from 61.5 to 118.1 barrels, with a mean of 87 barrels per acre.

The coefficient of correlation between the crop and the cost of spray material was 0.103 ± 0.178 which is of no significance. This indicates that this group of growers was approaching the margin where increased spray would not materially increase the crop. Nevertheless, the question of quality has not been considered, and it might be possible that the use of larger quantities was justified economically. To verify this point, the coefficent of correlation between the spray costs per acre and the farm income was determined and found to be 0.536 ± 0.049, which is very significant.

(The data appear to indicate that there might be a curvilinear correlation between the factors which would fit the data somewhat better than the simple correlation.)

An attempt was made to determine whether any relation existed between the crop and the different types of sprays and dusts. Differences were quite evident, but, treated statistically, the differences of 10 barrels per acre which appeared was not significant.

The results of a survey of fifteen scattered orchards the previous year showed a much higher coefficient of correlation between the factors in question, viz., 0.73—0.12. I am unable to explain this wide difference in the results but hope that further study of the problem will give more information on the subject.

I have been unable to find any record of similar work against which to check the findings of this study.

BEES AND POLLINATION OF THE APPLE. A REVIEW OF THE LITERATURE

C. E. Atwood

The question of the proper pollination of apple orchards is becoming increasingly important for two reasons. In the first place the modern tendency in commercial planting is toward large blocks containing only a few varieties; and in the second, the measures which are taken to exterminate pests also kill the useful pollinating insects.

Since Sprengel first realized the connection between flowers and insects, it has been generally recognized that certain plants need insect pollinators. Most writers regard the apple as belonging to this class. Cook, (1) as early as 1891, found that uncovered branches gave more fruit than those covered with cloth. Morris (7) states that wind is not important in the pollination of the apple as a 20-mile breeze did not carry pollen from one cluster to the next. Chittenden (8) tried to catch apple pollen on slides coated with glycerine and suspended near the trees, but found that none was obtained. Rawes and Wilson (9), Macoun (12), Ouenholser (2), Lagasse (23), and Wilson (26) all support the view that the apple blossom is entomophilous. This being admitted, the next question is "What insects are the most efficient agents for carrying apple pollen?" The general opinion is that bees do this work best, but there is some dispute as to whether the honey bee, the bumble bee, or the smaller bees of the family Andrenidæ are most efficient.

Waite (4) states that "where orchards are large and numerous there are seldom enough bees to pollinate them properly", thus indicating the need of a supply of honey bees for that purpose. Britton and Viereck (5) found that wild bees, especially Andrenidæ, far outnumbered hive bees on apple bloom. Wood (6) tells of two N.Y. orchards which had equal crops, one was supplied with honey bees, the other not; and considers wild bees responsible for the crop in the second case. Morris (7) states that many productive orchards have no hive bees within miles of them. Rawes and Wilson (9) believe that Bombi are most efficient, especially in cool or dark weather; Sax (10) believes Bombi very valuable in Maine; DeOng (14) thinks that wild bees are never present in sufficient numbers early in spring to be important; Hutson (16), Davis (18), Hendrickson (19), Hooper (24), Marshall (25) and Phillips all incline to this view. Barclay (21) in discussing the situation in New Jersey, mentions the fact that the country surrounding the orchard district is unsuitable for wild bee nests, and this factor is probably the controlling one. Places suitable for wild

bees will not need hive bees for pollination. In this connection it is interesting to note that Frison (15) has recently succeeded in domesticating bumble bees which in some circumstances are valuable pollinating agents.

A danger which menaces both wild and hive bees is the possibility of poisoning from fungicidal or insecticidal dusts or sprays. Cook (1) found that bees took poisoned liquid from the foliage of trees and were killed by it. Webster (2) and Webster (3) got similar results. Morse (11) considers that little poisoning occurs from contamination of flowers but rather from the sucking of spray drops and poisoned dew drops. Myers (13) regards dusting as a greater danger, because the dust not only covers the tree and contaminates the apple pollen, but also drifts for as much as two miles and falls on cover crops and wild flowers also. In 1923 he lost the crop from 180 hives from this cause. Garman (22) believes that wild bees are also suffering from dusting in Connecticut.

Admitting this to be the case, it is aparent that in many districts it will pay to have hive bees in the orchard during the blossom period. The number will vary with conditions. Hutson (16) recommends one strong hive per acre, but more exact work is needed along this line. Bees may be rented, owned by the orchardist and managed by a beekeeper, or owned and managed by the orchardist himself. The first two methods are probably best.

An example of the value of bees in a rather extreme case is given by Cole (17). Bees were introduced into the 1200 acre McClay orchard in Illinois to remedy light set. A hive was placed at every twelfth tree in every sixth row, the trees being forty feet apart. Many hives were not moved in until after full bloom. The crop of No. 1 apples was better than any previous crop by 14000 barrels, although nearby orchards had lighter crops than usual.

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CONTROL OF PLUM AND APPLE CURCULIOS

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Every year reports are received from growers of severe injury to the fruit of the apple by the plum and apple curculios. The principal reason for this injury would appear to be carelessness on the part of the grower, because our experiments and observations show that they are not particularly difficult to control. However, it should be pointed out that of the two species, the apple curculio is considerably more difficult to control, because of the difference in the amount of the surface of the fruit that is eaten in comparison to that consumed by the plum curculio. The apple curculio at each insertion of the proboscis only takes a portion of the surface large enough for the snout to enter the flesh, whereas the plum curculio in addition to this amount, feeds upon the skin sufficiently to form an arc of a circle. This is done presumably to check the growth of the tissue around the egg and thus prevent the egg being crushed from tissue pressure, but in doing this the beetle consumes more than ten times the amount of skin eaten in order to lay an egg. This important difference in feeding habits readily explains why the plum curculio is more easily controlled by arsenical sprays than the apple curculio.

The problem of control is considerably simplified by both species being single brooded. It is further simplified by both appearing about the same time in the early summer, or shortly before the blossoming period. This, logically, informs us that the poisons should be applied just before the blossom buds burst and again shortly after the petals start to drop. Since the cultivation of orchards, the presence of animals, or the picking up of fallen fruit, are methods which are not considered economical in the province of Quebec, then control must largely depend upon the application of arsenicals. This is particularly true of the apple curculio which transforms from egg to adult in the apple, when the fruit is little more than formed.

Several varieties of apples are attacked for feeding and oviposition in the early part of the season. They range from acid to sweet and from early summer to late winter sorts. However, the new brood of beetles, which appear about July 20, prefer golden russet and Alexander upon which to feed.

Duchess is a variety that is very severely injured, especially by the plum curculio and in the following control experiment it was the variety used. Trees bearing a full crop were dusted with a mixture of 45 sulphur-45 talc-10 calcium arsenate on May 24 and with the same mixture on June 4. The crop was examined and only 2 per cent was found injured. Other trees were sprayed with

lime sulphur 1,008 sp. gr. and 1½ lbs lead arsenate to 40 gals. on May 20 and June 4 with the result that 97 per cent of the apples were free from curculio injury. The check trees were located 50 feet away and had 100 per cent of the fruit injured, most of which was so distorted as to be unsalable.

In another series of experiments for the control of apple curculio the following results were obtained:

Pink bud application	—	Lime sulphur		1.007	—	calcium arsenate		2–40
Calyx	"	—	"	"	1.006	—	"	"	1¼–40
After calyx	"	—	"	"	1.006	—	"	"	1¼–40

When the counts were made it was found that 3 per cent of the crop had been injured, whereas not an apple escaped injury on the check trees. The variety was Alexander.

Lime sulphur appears to enhance the value of the insecticide, because in a set of check plots in the control of apple curculio out of 4,288 apples examined 31.9 per cent were infested; whereas, when lime-sulphur was added out of 4,498 apples examined only 14.8 per cent were injured. The variety was Talman Sweet.

Summary

a.—Studies of the habits of these insects indicate that the best time to apply insecticides for curculio control is during the late pink and early calyx stages.

b.—Generally, the plum curculio is more readily controlled, because it eats many times the surface of the fruit consumed by the apple curculio.

c.—Arsenicals applied in either liquid or dust form give satisfactory results in control.

d.—In experiments, controls of 97 or 98 per cent have been obtained on susceptible varieties, whereas nearby checks have been injured 100 per cent.

e.—Lime sulphur or sulphur dust increases the value of the insecticides in curculio control.

f.—Thoroughness of coverage is very important in control, especially in the case of the apple curculio. It would appear as though lack of thoroughness was responsible for most of the losses sustained by growers.

NOTES ON THE BORER MIXTURE CALCIUM CYANIDE AND RAW LINSEED OIL

C. E. Petch, Hemmingford, Que.

It was thought that the oil might become impregnated with the cyanide and further, after penetrating the bark and wood, the borers feeding upon the impregnated wood and bark would be readily killed. If the oil carried cyanogen it would make an insecticide that could be very easily applied and handled.

In order to ascertain the value of the above ideas, mixtures of Cyanogas Grade 'A' with raw linseed oil and Calcyanide No. 1 and raw linseed oil were prepared. The samples were submitted to Dr. J. F. Snell, Macdonald College, for analysis.

The oil was filtered from the mixtures and tested for cyanogen and calcium, —(1) by shaking with water and testing the water layer; and (2) by washing and testing the dissolved ash.

The results were negative in all the tests. The oil left only .03% of ash as compared with .12% in a sample of raw linseed oil in the laboratory. The possibility of hydrocyanic acid combining with the unsaturated fat of the oil was suggested by Mr. Bain, Macdonald College. Not only does this seem improbable but it is very doubtful if the product of such a union would be toxic.

"I think", says Dr. Snell, "we may safely conclude that the oil acts merely as an inert carrier of the poison".

In order to throw further light upon this problem the results of experiments conducted by the American Cyanamid Company, New York, were as follows.

"We have carried out our first experiments with mixtures of Cyanogas and oil. The problem, as I see it, would be one, first, of determining the rate of evolution of HCN from the Cyanogas in the presence of the oil compared with Cyanogas alone. After the hydrocyanic acid gas has been evolved from the Cyanogas, the next problem would be to what extent is it soluble in the oil and at what rate does the oil lose HCN, or rather, to what extent is hydrocyanic acid given off from a solution of hydrocyanic acid in the oil.

"In our experiments 'A' Dust alone lost 90% of its HCN in 2 hours time. A mixture of 'A' Dust and linseed oil lost 33.6% of its HCN in 2 hours and Cyanogas 'A' Dust mixed with Castor oil lost 46.2% of its HCN in 2 hours time."

'The method of carrying out these experiments was to make up the mixtures, spread them out in a thin layer and expose them to the atmosphere for two hours.

The residue was then examined for cyanide content. In the second experiment, mixtures were made up and the filtered oil was examined for HCN. In the case of the linseed oil and Cyanogas, immediately after preparation the oil contained .17% HCN. Three hours later the oil from the mixture contained .04% HCN. A mixture of Castor oil and Cyanogas, immediately after preparation tested .33% HCN, and three hours later .15% HCN.'

'A third experiment consisted in making a mixture of liquid hydrocyanic acid in the oil. It was found that linseed oil would only take up 15% of the liquid HCN but a 25% solution of HCN could be prepared in castor oil. Portions of this solution were exposed in an open 125 cc. Erlenmeyer flask for 24 hours at room temperature and then examined for HCN. It was found that the 15% solution of hydrocyanic acid and linseed oil lost 98% of its original HCN content in 24 hours, while the 25% solution of hydrocyanic acid in castor oil and Cyanogas lost 81% of its original HCN content.'

'This work might be briefly summarized by stating that castor oil reduces the evolution of hydrocyanic acid from Cyanogas and that the linseed oil reduces the evolution even to a greater degree than is true with castor oil. On the other hand, hydrocyanic acid is more soluble in castor oil than in linseed oil and the hydrocyanic acid gas is evolved from linseed oil more rapidly than from castor oil.''

Summary

1.—The value of the oil would appear to be in arresting the evolution of HCN. This would result in a more even distribution of the gas over a longer period.

2.—Raw linseed oil reduces the evolution to a greater degree than castor oil, in the first few hours.

3.—HCN is more soluble in castor oil than in raw linseed oil.

4.—Hydroyanic acid gas is evolved more rapidly from raw linseed oil than from castor oil in the later hours.

5.—Tests have shown neither oil has any advantage when employed in the field, so far as control is concerned.

6.—The oil merely acts as an inert carrier of the poison.

THE APPLE AND THORN-LEAF SKELETONIZER (HEMEROPHILA PARIANA CLERCK)

By J. M. Cameron.

History and Distribution

This insect is of European origin and has been known for over 160 years. Frequent reference is made to it in European literature. It has been recorded from England, France, Germany, the Balkan Peninsula, Bithynia, Russia, Norway, and west in Asia to Turkestan (2) *

Reference was also made from Japan in March of 1922 (4).

It was first discovered in America in 1917 by Dr. E. P. Felt. He found it in the lower Hudson Valley. It spread rapidly and was reported from Connecticut in 1920 (3). For the next three years the annual reports of the State Entomologist mention it as spreading and becoming quite serious. In 1924, however, it practically disappeared, a fact which was credited to natural enemies (11). In 1917 it was established in Ontario (2) and late in 1922 was found in Massachusetts (6).

In 1924 a caterpillar was found feeding on thorn in Nova Scotia, and it was thought to be the larva of this species (9). It has now spread throughout the apple-growing district of the Province, extending beyond the commercial section. Last fall, while scouting about the orchard at Macdonald College, the writer found the cocoons there. This is the first record found of its presence in Quebec Province.

Food Plants

In America the favorite food plant of this insect is the apple, but it has also been recorded as injuring to a lesser extent thorn and pear. It has been recorded in one instance each from peach, sweet cherry and strawberry (9). In Europe it is reported from apple, thorn, pear, mountain ash, birch, one species of plum, and possibly willow (7). In Canada it chiefly attacks the apple, but has been recorded as feeding on thorn, and the writer has found it on strawberry.

Injury

The caterpillars feed, either singly or in groups of two or three, on the upper surface of the leaves, skeletonizing them. They feed from the basal part of the midrib upwards and outwards, so that in moderate or light infestations

* Numbers in parenthesis refer to literature cited.

there is often an untouched portion at each margin at the base of the leaf. As the larva feeds, it spins a light web over the surface of the leaf, drawing the two margins together, especially towards the tip. The leaves are not webbed together as in the case of the fall webworm.

The extent of the injury on each leaf varies from a small section to the entire surface, depending greatly on the severity of the infestation. In very severe cases an entire tree or even an orchard may be defoliated, particularly in unsprayed orchards. The foliage of a severely injured tree appears, at a short distance, as if scorched by fire, and in late summer and early fall many of the leaves drop to the ground.

Economic Importance

Since its introduction, this insect has caused serious damage in many of the apple-growing districts of northeastern America. This is particularly true in small home orchards, in orchards which do not receive proper attention, and on roadside trees. In such cases, when the infestation becomes severe, defoliation often results. This weakens the tree, reduces the stored food and lowers the vitality of the buds for the coming season.

Commercial growers may expect comparatively little trouble from this insect, as the routine sprays serve to keep it fairly well under control. Where it secures a foothold and becomes very severe, it is possible that after a short time it may be checked to a considerable extent by its natural enemies. The writer knows of one case where, in a neglected orchard where the infestation had become quite severe, it was practically cleaned out by an attack of parasites. The greatest danger to the commercial grower is that these unsprayed orchards will serve as a point of infection for the larvæ of the second generation, so that an orchard may be infested a considerable time after the last spray has ceased to be really effective.

European literature is somewhat vague as to what the exact economic status in Europe is, but it seems that, in some seasons at least, it is a quite important pest.

Life History and Stages

Complete and accurate studies of the life history in this country have not been carried out, but enough is known to state that there are three generations, and perhaps a partial fourth in some seasons, in Connecticut and the other more southern districts in which it occurs (7), while in the more northern ranges there are only two generations. It is recorded as having three generations in Europe.

Life history studies made in Nova Scotia in 1929 indicate that the stages are about the same as in other countries. The winter is passed usually as a

moth, probably among moss, leaves, and other such protection. According to some authorities some pupae also may remain over winter, but Porter and Garman (7) found that this was not the case in Connecticut. In Nova Scotia also all the moths had emerged by the first part of October. The moths come out of hibernation and the eggs are laid probably as soon as the leaves begin to develop in the spring. In Connecticut larvae were found in various stages during May, and pupation had begun as early as May 28th. (7). In Nova Scotia pupation began about the end of the third week in June. In about two weeks the moths emerge.

The newly hatched larvae begin to feed at once on the under side of the leaf on which the eggs were laid. A group of caterpillars usually feed together and a delicate web is spun over the feeding area. To this web are attached the particles of excrement. After feeding for three to five days the larvae become quiet and in a short time moult. After the first moult they feed either singly or in groups, usually migrating to the upper surface of a new leaf or to an uninjured portion of the same leaf. Here is spun another web under which feeding takes place. In two to six (average four for the summer generation) days moulting again takes place. The third instar larvae usually wander to a certain extent, and finally settle down on the upper surface, usually of a new leaf and most often singly. Here again feeding takes place beneath a web and continues for about five days and then the third moult takes place. After feeding for about a week, construction of the cocoon is begun.

The cocoon is constructed in a fold of the leaf, either the one on which the larva has been feeding or a new one. The fold is formed by drawing the sides of the blade together by means of a web, and may be on any part of the leaf. There may be from one to several on one leaf. The cocoon consists of five distinct webs (13). The inner one is from 18 to 20 mm. long by 2 mm. wide, and the outer one is 25 to 30 mm. long. The two inner webs are spindle-shaped and the last larval skin is thrown out at one end. Within 48 hours after the beginning of the construction of the cocoon pupation is complete.

The moths are day fliers and are to be found on flowers of all kinds from the time of emergence until the frost becomes so severe as to kill the flowers, when the moths are forced to go into hibernation. They fly usually for about four weeks.

A description of the various stages of this insect is as follows:

The Egg:—(7 & 13). More or less hemispherical in shape and often slightly longer than wide, measurements being as follows: length—0.39—0.44 mm., average, 0.41 mm.; width—0.33—0-44 mm., average, 0.38 mm.; height—0.19—0.28 mm., average, 0.23 mm. The partially flattened side is usually placed next the leaf surface. The egg is soft, thin-shelled, and has 13 ribs radiating from the rounded apex and connected by transverse bars. When first laid

the egg is pale green, but after a few days becomes yellowish and may show a brownish ring having a diameter about half that of the egg, and varying in width.

THE LARVA:—*First Instar:* Length, partially fed,—1.5 mm; length, full fed, (7)—2.0 mm. Width of head—0.20—0.50 mm., average, 0.30 mm. The body is distinctly annular. The tubercles are not visible. The head is considerably wider than the rest of the body. Color, white or yellow; head yellowish brown with the posterior lateral margin darker. Ocelli on the margin of a darker spot on the side of the head, Prolegs and thoracic legs translucent.

Second Instar: Length—4.5 mm. Width of head—0.30—0.46 mm., average, 0.38 mm. General color pale whitish green with the tubercles showing distinctly as light brownish spots. Head yellow with dark posterior lateral border. Ocelli dark. Tips of the mouthparts brownish. Legs and prolegs pale and translucent.

Third Instar: Length—6.1 mm. Width of head—0.53—0.79 mm., average 0.64 mm. General color yellowish with the tubercles showing distinctly as large, dark brown spots. Head yellow with dark posterior lateral margin. Ocelli rather dark. Tips of mouthparts brownish. Two dusky spots resembling eyes on the top of the head. Legs brownish distally. Prolegs pale and translucent.

Fourth Instar: Average length—10.3 mm. Width of head—0.79—1.04 mm., average, 0.96 mm. General color yellowish with prominent black tubercles. Head light yellowish brown with black posterior lateral margin. Ocelli black. Mouthparts dark-tipped. A pair of dark spots on the upper part of the head. Ventral surface paler than dorsum. Last two segments of thoracic legs dark, especially the next to the last. Remainder about the same color as the body. Prolegs slender, pale and translucent. A thick coating of short setæ over the entire surface of the body.

THE PUPA:—Length—6.86—7.75 mm., average, 7.26 mm. Width at widest point—1.83—1.91 mm., average, 1.85 mm. Blunt at the ends. At first a creamy yellow, later becoming darker, the head and terminal abdominal segments becoming almost black. The eyes are light brown. The spiracles, eyes, wings, legs, antennae and mouthparts may be seen. The prothorax and anterior portions of the meso—and metathorax are darker than the rest of the pupa. On the anterior border of segments three to eight in the male (7) or three to seven in the female (7) is a single row of very fine, short, dark-colored spines. Segment 10 has two short, coarse, dorsal spines. A few fine setae are distributed over the body. The adbomen is quite flexible and if disturbed the pupa wriggles back and forth the length of the cocoon. When emergence is about to take place the pupa wriggles its way through the end of the cocoon opposite that at which the larval skin is forced out, and the skin bursts, allowing the moths to escape. The pupal stage lasts about two weeks.

THE ADULT: The adult is a small, dark reddish-brown moth, often having the wings crossed by irregular darker and lighter stripes or by a paler band. The marginal scales of the wings are a dark brown. Sometimes there are white spots along the costal margin, particularly near the outer angle. Hind wings with a silvery stripe along the costal margin, extending somewhat more than half the length of the wing from the base. The fore-wings are lighter beneath, with white spots along the costal margin, and the anal area silvery gray. The hind wings are somewhat darker than the fore-wings in ground color, and are liberally speckled with gray.

The labial palpi are three-segmented, liberally clothed with scales, white on the basal half and brown on the remainder, and extend beyond the head about the length of the third segment. The antennæ are moniliform and clothed with alternating white and dark brown scales. The compound eyes are quite large and dark brown in color. Ocelli are present.

The body is clothed with dark brown scales, those on the sides of the abdomen, and sometimes at the posterior edge of the segments, being gray-tipped. The legs are clothed with brown, gray-tipped scales except the tarsi, which have alternating encircling bands of brown and white scales. Length of body about 5 mm. Length of forewings 4.8-5 mm. Wing spread about 11 mm.

Natural Enemies

In many cases the skeletonizer may be adequately controlled by natural enemies. There are quite a number of these, birds as well as insect parasites and predators. Porter and Garman (7) report chipping sparrows feeding on the larvae, and a small Pentatomid, a species of *Podisus*, sucking the juices from a small larva. They report moths having been captured by a spider and by an ambush-bug of the family Phymatidae.

Several parasites have been reared in Connecticut and New York, and eight in Nova Scotia. Four of these last are the same as those reared in the States, and at least two are also parasites of the eye-spotted bud moth. The following have been reared in Connecticut (7):

(*Habrobracon*) *Microbracon gelechiae* Ashmead.
Dioctes obliteratus Cresson.
Sagaritis sp.
Exochus propinquus Cresson.
Dibrachys boucheanus Ratzeburg.
Exorista pyste Walker.
Phorocera tortricis Coquillet.
Nemorilla maculosa Meigen.

Schott (12) records *Dibrachys boucheanus* Ratzeburg and *Epiurus indagator* Cresson as beng bred from the cocoons in New York. He also records the

appearance of *Itoplectis conquisitor* Say, *Triclistus curvator* Fab., a Pteromalid, a species of *Horisemus*, and *Comedo anomocerus* Crawford as appearing in connection with the skeletonizer, but does not know whether or not they are parasites. At least two of these, namely *I. conquisitor* Say and *T. curvator* Fab. were reared from cocoons of the skeletonizer in Nova Scotia, so it is probable that at least these two are parasitic in New York also. Schott also records the attack of the larvae by the reduviid bug *Sinea spinipes* H. S.

In Nova Scotia the writer reared the following from cocoons gathered in the orchards:

Itoplectis conquisitor Say.
A species of *Itoplectis*, probably the undescribed male of *leavitti*.
Epiurus indagator Cresson.
Phaogenes sp.
Triclistus curvator Fab.
Microbracon gelechiae Ashmead.
Sympiesis bimaculata Crawford.
Nemorilla floralis Fallen.

These were determined through the kindness of Dr. Harold Morrison of the United States Bureau of Entomology.

From Europe the following have been reported as attacking the skeletonizer (7).

Angitia glabricola Holmgren.
Mesochorus pectoralis Ragonot.
Microgaster sp.
Thryptocera crassicornis Meigen.
Minkiewicz reports the following from Russia (13):
Pimpla alternans Grav.
Pimpla sagax Hartg.
Mesochorus testaceus Grav.
Eulimneria fuscicarpus Thoms.
Dibrachys boucheanus Ratz.
Pteromalus sp.
Apanteles albipennis Nees.

Minkiewicz also suspects the destruction of the larvæ by *Triphleps minuta* L. and *Forficula auricularia* L.

Of the eleven species described from Europe only one, *Dibrachys boucheanus* Ratz., has been found attacking the skeletonizer in America.

That natural enemies may be very efficient in the control of this pest was shown in Connecticut. Here, from the time of its introduction in 1917, it

increased steadily in numbers and importance until 1924. In that year it was very conspicuous by its absence, for which credit is given by the State Entomologist to its control by natural enemies (11).

Control

Where this insect becomes unduly abundant it may be taken as an indication of poor spraying or lack of spraying in the orchard. Owing to their exposed feeding on the upper surface of the leaves the larvae are easily controlled, and a thorough and timely application of arsenate of lead is sufficient to keep them in check. The ordinary spray schedule will probably be sufficient under ordinary conditions. If only two after-blossom sprays are applied, a special application of poison about the first or middle of July may be needed if the larvae are abundant. The calyx application alone is usually sufficient to control the first generation larvae, the later spray, where necessary, being for the second generation.

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SUMMARY OF THE PAPERS ON ORCHARD ENTOMOLOGY

Dr. W. H. Brittain, Professor of Entomology, Macdonald College.

The task assigned me should be the easiest one of any on the programme, since it consists only of gathering up the scattered threads and attempting to emphasise or throw into relief the main points made by the other speakers on topics in orchard entomology. It would have been still easier had I been privileged to study the various papers of the different men taking part in this symposium, as was the original intention; but since this was not the case, this summary must be largely extemporaneous and not the result of careful study of the individual papers.

Oil Sprays

So rapid has been the advance of oil sprays within the last few years, and so abundant and so technical the literature on this subject, that it has puzzled many entomologists to keep up with the subject. The very clear and comprehensive summary of Mr Herman's will be of assistance in this respect.

Fortunately the necessity for using these sprays in Quebec orchards at present does not obtain. Should the European red mite assume the importance that it seems to have done in certain other districts, the need may well arise at any time. Meanwhile we are glad to have this addition to our information regarding this important group of insecticides.

Spraying

Father Leopold's contribution reminds us that applied entomology has strong engineering aspects, that we owe much of our recent progress to improvement in equipment-- in fact that all our modern advances in other fields would have been useless without the corresponding improvement in the technique and machinery of spraying. We have seen this field grow, until within ten or fifteen years heavy duty power outfits have become more common than the more primitive hand outfits were fifteen years ago. During the last few years the tendency has been to concentrate on the nozzle or the device, whatever it may be, for breaking up the liquid and ensuring the type of spray considered most desirable.

In this machine we have one method of effecting this result, namely, the breaking up of the stream by means of a blast of hot air. It will be interesting to watch what the manufacturers will have in store for us during the next few years, and what ultimately will be the type of applicator that will supersede the others. Meanwhile we are grateful to Father Leopold for his description of this outfit and its working.

Insects and Pollination

The question of pollination is one that has come very much to the fore during the past few years. In the early days of the home orchards varieties were usually sufficiently mixed to ensure that during bloom all would be assured of an adequate supply of pollen of compatible varieties. Two things have happened in recent years to change this picture. One has been the planting of large blocks of desirable varieties without due attention to the pollination factor. The other has been the decline in the insect fauna responsible for pollination. This decline is partly due to the increase in the cultivated areas that have progressively decreased the area available for suitable nesting places of our wild species, particularly Bombidae, and partly due in some cases, to the use of poisonous dusts that have reduced the population, not only of hive bees but of wild bees as well, as shown by work carried out by the speaker last summer. There has thus occurred not only an insufficiency of effective pollinizers but also of pollinators. To meet this situation and to assure a sufficiently large population of pollinizing insects to take care of the greatly increased acreage in fruits, various experimental stations and other organizations, as indicated by Mr Atwood's review, have recommended the placing of definite numbers of colonies throughout the orchard. They have also recommended the setting out of pollinizing bouquets until top grafting can be carried out. Some excellent work has undoubtedly been done, though the actual recommendations as to number of colonies, placing of the colonies, use of bouquets, etc., seem in many cases to be based on rather slender data and the role of wild bees does not always seem to have been given its due importance. The use of package bees from the South has been promoted by certain official organizations though packet colonies have a very weak working force and it may take several of them to equal the value of a single strong overwintered colony. The statement has been made that, with respect to their pollinizing activities, there is a concentration of bees near the colonies and evidence has been adduced to support this. It would appear, however, from our observations that this depends on many circumstances. For example, it will be stated that a certain orchard never had more than a certain number of barrels until bees were placed in the orchard—a great increase has resulted. To those who have been associated with orchard work for some time, such sudden increases are by no means uncommon even without this possible cause, and in many cases quoted, the possibility of some other factor being operative does not appear to have been given due consideration. This is not intended to minimize the importance of the role played by these insects, which of course is an essential link in the chain of factors making for fruit setting. Our own work furnishes some rather spectacular examples of its importance. Caged trees from which bees were excluded in no case, even in self-fruiting varieties, set a marketable crop of fruit, whereas, under similar conditions, the same varieties set excellent crops when supplied with bees and bouquets of blossoms of an

effective pollinizer. There are many details, however, in connection with the commercial utilization of the colonies that reamin to be worked out.

Curculios and Round-headed Borers

Curculios seem to be a major pest in Quebec, more so indeed than in most fruits growing districts. Why this should be so is not possible to say, though the relatively large amount of waste land and the prevalence of the grass mulch system may be a factor. If it is as important a factor as one might be led to suppose, and if what is called "orchard sanitation" is as necessary as some writers would seem to indicate, then it is difficult to see how apples can be grown at all in this province. A study of the literature on these pests reveals considerable differences in the recommendations made for their control. Where arsenical sprays are recommended we do not find unanimity as to which application is most important. There seems to be a general agreement among those who have actually worked on the problem that, of the two, the apple curculio is less amenable to arsenical sprays, Indeed, Fulton (Journ. Agr. Res., 36; 249-261, 1928) states that there is "little hope" of controlling apple curculio by this means and that neither orchard cultivation nor destruction of wild host is effective. He recommends pasturing of hogs, which, under our conditions seems like a counsel of despair. That Mr. Petch has been able to secure effective control of this species by arsenical sprays alone, will no doubt be a source of satisfaction to those who have to contend with this pest.

A simple and effective remedy for round-headed borer is something that has been badly needed for many years. According to Mr. Petch this long left want has now been satisfactorily filled by his new linseed oil cyanide mixture and we can only hope that further reasearch may open up still more uses for this material.

Apple and Thorn Skeletonizer

The introduction of a new pest into any district is always a matter of interest. A feature of this pest's introduction is the rapidity with which it has spread and it will probably not be long before it is found in all our fruit-growing aeras. The first question that arises, is how important is it likely to be and, the second, how is it controlled? Answering the second question first it appears as Mr. Cameron has said that the pest is readily controllable by the sprays customary in good orchard practice, though some injury from the second generation may be looked for even in well sprayed orchards and it may be necessary to give more thorough treatment to young non-bearing orchards. As for the first question, it would appear that the hopes of some of us for the introduction of a new pest, readily controllable by native sprays that would, nevertheless, put the non-sprayer out of business, are likely to be dashed to the grounds. The effective way in whish parasites of related species have attacked this species, as if they had been doing so from time immemorial, would seem to make

it unlikely that, unlike many other introduced forms, the apple and thorn skeletonizer was going to be much more important than in its native home. It seems more likely that it will merely add itself to the list of pests with which we already have to contend without presenting any special problem.

CONTROL OF APPLE SCAB IN THE QUEBEC REGION

Omer Caron, Provincial Botanist, Quebec.

While orcharding in the Quebec region does not have the same importance that it has in the Montreal region, it nervetheless deserves some attention, since around Quebec, especially in the counties of Quebec, Montmorency, including the Isle of Orleans, and Levis, there are localities where the production of fruit accounts for fifty per cent of the revenue of a large number of farms. We have known for a long time that the question of pest control in this region deserved some attention, but our staff has been too small to give it this attention hitherto.

I wish to outline here an example of what might be done in the way of a systematic organization for the protection of orchards, by reporting the work done last year in the parish of St. Nicholas, in Levis County.

During the autumn of 1928 an event occurred which put us in intimate contact with the farmers of this parish and which was the direct cause of our organization for scab control in 1929. The results of this work while not perfect, were as far as we could judge, quite satisfactory.

In September 1928 the Levis County Agricultural Society organized an orchard competition in the parishes of St. Nicholas and St. Etienne. Mr. Maurice Talbot and myself were asked to judge in this competition in which some thirty growers took part. This gave us the chance to make an examination such as we do not always have an opportunity of doing. Among thirty orchards visited we had difficulty in finding three or four which were in a satisfactory condition from the standpoint of the state of the trees and the quality of fruit harvested, this quality depending of course on the care which had been given to the trees. Only five or six growers practiced the spraying recommended, one had given four sprays and the others fewer. It is interesting to note that in the orchard where four applications of spray had been given we did not find a single spotted apple or leaf after examining some thirty trees. Here was a good example of what might be done by a willing grower at a slight expense. It is true that the orchard was in a good location and separated by a considerable distance from the others. Evidently an organized scheme of pest protection was necessary here. This we put into effect in 1929.

During the following winter we held several meetings in St. Nicholas and obtained the signatures of twenty growers who undertook to follow our instructions. We distributed or advised the purchase of one ton of nitrate of soda, seventeen barrels of lime-sulphur, 1500 pounds of arsenate of lead, and several hand sprayers.

It has not been possible to follow these growers as carefully as has been done in the Montreal district, but we made them several visits during the summer and by August we had very tangible evidence of the good results of our propaganda. Following is an estimate of the quality of the harvest during the two years of our observation.

	1928	1929
Choice apples	5%	60%
Saleable apples	50%	85%
Culls	45%	15%

These calculations were made in September. The season of 1929 having been very favorable to the development of scab, we visited several growers who were not included in the scheme and found that they had obtained practically the same results as in 1928. It should be noted here that in 1929 a very important spray was omitted following our instructions because of the very unfavorable temperature at the time when it should have been applied.

In Ste. Famille on the Isle of Orleans where one of our instructors is stationed, and where considerable crop protection work has been done, the results obtained were also very good but not as remarkable as at St. Nicholas because the orchards in the former parish were in a better condition to start with.

We believe that if the growers will purchase better spraying machines the improvement will be still more marked. At Ste. Famille several growers purchased motor sprayers last spring and they have been quite satisfied with the service obtained from these machines. I do not know whether it will be possible this year to base our work on the very exact observations made in connection with the spray service in the Montreal district, or whether we should wait another year and obtain more exact information on the use of spore traps. In the meantime what is very encouraging is that the growers are satisfied and have accepted our intervention willingly.

These notes offer nothing new to those who know the importance of adequate orchard protection, but I give them here to point out the good results which might follow a single season's work.

THE CONTROL OF APPLE DISEASES IN QUEBEC IN RELATION TO CULTURAL METHODS

H. N. Racicot, Plant Pathologist, Division of Botany, Central Experimental Farm, Ottawa, Ont.

In the Province of Quebec, the control of diseases, except apple scab, fire blight, and a few others, resolves itself largely into proper cultural methods and sanitary practices. In Quebec the apple growing districts are not far from the northern limits where apples can be grown commercially. This has its advantages and disadvantages. There are less parasitic diseases, and more disorders due to climatic and related conditions, followed by weak or secondary parasitic diseases.

Winter Injury

Winter injury or killing is favoured mainly by too late maturing of new wood. This is brought about by many conditions. The use of improper fertilizers, which prolong growth, is chiefly responsible. Cases have been known where fresh barn manure had been applied in the spring. This prolonged growth into fall, and the new wood was killed every winter.Consequently these trees never bore a crop. Nitrogenous fertilizers applied to the orchard should be in a form readily available to the trees, such as nitrate of soda. Lack of humus in the soil may best be corrected by a straw mulch. This also accelerates bacterial action which makes the nitrogenous substances in the soil available earlier in the season to the trees. The lack of fertilization, and therefore too poor a soil, causes the trees to make a slow and prolonged growth. Such trees are very subject to winter injury or killing.

Too severe pruning tends to increase and prolong new growth, which is subject to winter injury or killing. It also exposes the trees more directly to the sun's rays, with consequent increased danger of sun scalds during bright sunny days late in winter. Trees with long trunks from the ground to the lower branches are more subject to sun scald injury than trees whose lower branches are close to the ground. In all these cases, white-washing the trees late in the fall would prove beneficial. The white-wash reflects the sun's rays, and keeps down the temperature of the trees.

Diseases that Follow Winter Injury

There are a number of parasitic diseases that can only attack weakened trees, or trees with wounds. Sun scalds and other winter injuries weaken trees,

or cause the bark to split, permitting the entrance of micro-organisms such as black rot canker, silver-leaf, *Fomes*, etc. Trees that have suffered from winter injury should be well sprayed, and diseased limbs should be pruned and *burned*. If they are not burned, many of these diseases can develop on the dead limbs and produce spores. Therefore, these diseased limbs should be destroyed immediately. Spraying the trees, and pruning and burning the diseased limbs, will protect other weakened trees or limbs, and give them a chance to recover before they are attacked by such diseases.

Collar Rot

Collar rot, in my opinion, is a form of winter injury and occurs chiefly in poorly drained soils that are wet during fall and winter. Trees attacked by borers appear to be more subject to collar rot than other trees. Good drainage is the only preventative, while bridge grafting will often save trees that are already injured.

Sanitary Practices

Branches that are pruned should be cut close to the place of attachment, in order to enable the wound to heal over quickly. If large branches are pruned, the cut surface should be painted over with paint made from white lead and linseed oil.

Cankers and other fungous growth should be removed, cutting well into the healthy wood. The surface should then be washed with mercuric chloride and painted over.

Deep Snow

In Eastern Quebec most orchards have spots where the snow collects sometimes as high as 8 or 10 feet, usually near clumps of trees, wind-breaks, buildings, etc. When the snow melts in the spring, it becomes wet and very heavy, breaking down limbs. This injury occurred nearly every year in two or three rows of trees near the wind-break in the orchard of the Experimental Station, Ste. Anne de la Pocatière. This injury has been almost entirely prevented for five years now merely by scattering a little coal dust around the trees late in winter. The particles of dust absorb the rays of the sun, which causes much of the snow to melt while it is yet dry and light.

RASPBERRY DISEASES AND THEIR CONTROL IN QUEBEC

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This paper deals only with the raspberry diseases that are of economic importance in the Province of Quebec at the present time. The discussions here are based on observations made during five years of inspection and certification of raspberry plantations, and deal with only four diseases, namely mosaic, leaf curl, spur blight and anthracnose. The first two are virus diseases, and the last two fungous diseases, caused by the fungi *Didymella applanata* (Niessl.) Sacc. and *Plectodiscella veneta* (Speg.) Burk, respectively.

With the exception of two or three plantations of Columbia which is a purple or hybrid raspberry, all the raspberries grown in the Province of Quebec are red raspberries. As far as I know there are no black raspberry plantations in the province. The chief varieties grown are Herbert, Newman and Cuthbert. The Herbert and Newman raspberries are grown in all parts of the province, while the Cuthbert variety is practically limited to the Isle of Orleans, where it was introduced some 20 or 25 years ago.

Mosaic

The type of mosaic found in this province corresponds pretty well with the type called by Bennett (2) red raspberry mosaic, and my observations so far would lead me to believe that we have only the one type. It causes distinct mottling. The foliage is yellowish-green with raised dark-green spots. The plants after being diseased one or two years, become more and more stunted, and the berries produced are smaller and dryer than those on healthy plants. Under our conditions, mosaic reduces the yield by about 50%, and mosaic plants are subject to winter injury. The Newman variety is very susceptible to mosaic, with Cuthbert a close second. Occasional traces of mosaic are found on the Herberts. The only plantation of King raspberries that has been observed in Quebec had 100% mosaic. A few garden plots set out with Golden Queen raspberries also had 100% mosaic.

From five years observations, I have found that raspberry plants affected with mosaic cannot be detected with certainty before about the first of July. This is due to cold, or cold and wet weather in the spring, which causes abnormal leaf conditions, such as yellowing, browning and rolling. These make mosaic difficult to diagnose. Furthermore, my observations lead me to believe that under Quebec conditions there is very little current-season symptoms on newly inoculated plants. The reason for this is the lateness of the appearance of aphids, the transmitting agents of raspberry mosaic. The earliest that I have observed

aphids on raspberries in Southern Quebec was on the 18th of July. Usually aphids appear at the end of July or beginning of August. Occasionally it is later than that. This gives only an average of one month for infection to take place, and very little time for current-season symptoms to show up.

Control. From the above discussions, it is seen that under our conditions, mosaic should be easily controlled. By the first of July, it can be detected with certainty, and aphids do not appear before the fifteen of July at the earliest. This gives the growers at least two weeks to rogue their plantations before infection has taken place. However, it will not be economical to rogue all plantations. This will depend on the age and density of the plantation and on the percentage of mosaic. As a rule it will only be practical to rogue plantations that are not more than 3 years old and that have not more than 5% mosaic. If the plantations are planted closer than six feet between the rows and three feet between plants in the row, and soil conditions have permitted rapid growth, it may only be practical to rogue plantations two years old. In older plantations, and in plantations planted too densely, the roots of one hill run under and even pass beyond other hills, and it is impossible to remove them all. Consequently diseased suckers are always coming up from pieces of roots left in the ground, which are a source of infection for the rest of the plantation. In Quebec new plantations are usually set out in the spring with year old or fruiting canes. It is always difficult, in fact often impossible, to detect mosaic on fruiting canes in our climate, due to weather conditions in the spring when leaves on fruiting canes were formed. Therefore the best time to rogue a plantation is during the first two weeks in July and when it is one year old, or the next season after it has been set out. Mosaic can then be detected with certainty, the whole of the diseased plants, roots and all, can be easily pulled out or dug up, and the infection of healthy plants has not yet taken place. If plantations are rogued after aphids have appeared, care must be taken in the disposal of rogued mosaic plants. These must be carried out and to a considerable distance from the plantation, in order to prevent aphids from crawling off wilting plants on to healthy plants. Otherwise a larger number of healthy plants may become infected than the number of diseased plants that have been rogued out.

Leaf-Curl

The symptoms of this disease in the Province of Quebec correspond exactly with those described by Rankin and Hockey (3), Berkeley & Jackson (1) and Bennett (2). The foliage of the diseased plants is a darker green than that of the healthy plants. The midrib and the main lateral veins curve downward, causing a downward curling of the entire leaf margin. The tissues between the veins are folded upwards. The net result is a curled and crinkled appearance of the leaves. The lead-curl plants become progressively stunted from year to year. They are more subject to winter injury, and are often completely winter killed. On the Isle of Orleans, where the Cuthbert varity is grown and this di-

sease is prevalent, the part of the diseased canes above the snow is killed every winter. The berries are small, dry and seedy and usually dry up before ripening, or they crumble in the hand when being picked. Leaf-curl causes at least 90% loss of crop under our conditions. Leaf-curl in Quebec is found almost exclusively on the Cuthbert variety. The symptoms are evident from the time the leaves are out on the plants until the frosts in autumn kill the foliage. As in the case of mosaic, aphids are the transmitting agents. Leaf-curl should be easier to control than mosaic, as it can be detected with certainty earlier in the spring, giving the grower longer time to rogue his plantation before aphids are able to infect new plants. If the rogueing is done only after aphids have appeared, the same care should be exercised in the disposal of the rogued plants as in the case of mosaic, in order to prevent aphids from crawling off the wilting plants on the healthy plants. Otherwise the number of newly inoculated plants may be greater than the number of diseased plants rogued out. New plantations should only be set out with disease-free stock.

Spur Blight

This is a fungous disease attacking mainly the Herbert variety. However, traces of this disease are to be found on Cuthbert and Newman raspberries. It causes purplish brown or tan to black spots on canes. Infection usually takes place in the axils of the leaves of the first year canes. From there the spots spread upwards and downwards and around the stem, sometimes completely encircling it. Infection is confined to the outer bark, and apparently does not affect the first year's growth. The fungus may also attack leaves and fruit. The real injury is the killing of the buds that would grow, the following spring, into the lateral branches which produce fruit. When the disease is severe, all the lower buds are killed, and, the following spring, only a few lateral branches at the top of the canes grow out to produce berries. In 1926 this disease was so severe in some Herbert plantations in the Montreal district that the canes only had two or three branches at their summit producing berries. These canes looked as if they had been pruned. In these plantations there was a loss that year of at least 90%. The average loss in all the Province on the Herbert variety has been about 15% each year.

Infection takes place in spring and early summer mainly from ascospores produced on fruiting canes, where the disease has overwintered. Theoretically the disease should be controlled by spraying the young suckers once a week from the time they emerge out of the ground until about flowering time. Sackett (4) reports good results by spraying with Bordeaux mixture in Colorado. Other pathologists, on the other hand, report that spraying with Bordeaux has not given satisfactory results. Other methods of control of value are wider spacing between the rows, when setting out a new plantation, and thinning out the canes in the rows when cutting out the old fruiting canes. This allows better ventilation, and helps to prevent the spores from germinating and infecting the young canes.

This disease, when at all severe, seriously affects the value of canes for planting. Canes are usually cut back to one and a half or two feet when planted. If spur blight is at all severe, it kills the buds that remain on the canes, and these canes do not leaf out, but dry up and die.

Anthracnose

Last summer (1929) was the first season that I have observed this disease to be of economic importance in Quebec. This was in three plantations of the Newman raspberries, being severe in one plantation and moderate in the other two. It is believed that the excessively wet spring was favourable to the development of this disease. Wild raspberries affected with anthracnose were observed near two plantations, and it is believed that they were the source of infection. The disease may again become unimportant if weather conditions are normal in the spring of 1930. Anthracnose is a difficult disease to control, and in case it should continue to be of importance, the chief methods of control are outlined here. These are (1) spraying with Bordeaux mixture, (2) removing fruiting canes as soon as the crop has been picked, (3) cutting out the new canes badly infected, (4) digging up badly diseased hills, as the disease becomes perennial in the stubs or roots, (5) burning all diseased material removed from plantations, (6) destroying all the wild raspberries in the neighborhood of plantations, (7) and setting out new plantations with disease-free stock, and at some distance from old plantations.

Inspection and Certification of Raspberry Plantations

From the standpoint of disease control it is very important, that new plantations be set out with canes that are practically free from disease. This is only possible by a system of inspection and certification of the plantations from which canes will be sold. Such a service was begun in 1926, and has since proved to be of decided value.

In order to assure its continued success, growers must continue their cooperation with the plant pathologist. It would be advisable for a number of growers to specialize in the production of certified raspberry canes. The control of all the four diseases of economic importance in Quebec calls for disease free stock with which to set out new plantations. Purchasers are advised to purchase only certified stock.

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THE FIRE BLIGHT PROBLEM

By J. E. Machacek.

Fire blight is a serious bacterial disease of pomaceous and stone fruits, especially the latter, which has established itself a relatively short time ago in the province of Quebec, and has been located in many orchards in the south third of the province. Though the losses from this disease are as yet not large, it is well for apple and plum growers in the yet uninfected localities to keep a constant watch for the symptoms, and when they are observed, proper precautions must be made to prevent the spread of the disease.

It is probable that this disease is native to North America, inhabiting many wild hosts in the absence of the cultivated. The first report of this disease was made by William Denning in 1780, who discovered the disease on trees in the Hudson river valley in New England. From this small start the disease has spread by leaps and bounds, so that in 1817 it had already been recognized as one of the important factors in fruit production. The spread of the disease appears to have been chiefly southward, as the westerly ranges of mountains somewhat inhibited its progress. By 1876 considerable damage through this disease was reported from Illinois and the northern Mississippi valley. About this time orchards along the coast of the Gulf of Mexico were completely devastated. California was reached by the disease in 1900, and from that state its spread northward was very rapid, so that very disastrous epiphytotics of the disease occurred in the states of Oregon and Washington. Afterwards the progress northward was slower, the Niagara peninsula of southern Ontario showing signs of the disease in the orchards about the begining of the present century, while the orchards of British Columbia suffered from the disease shortly after its invasion of Oregon and Washington. At the present time the disease has been located in every province in the Dominion of Canada except Saskatchewan and Alberta. A few localities have been reported as uncontaminated, especially those parts of Illinois and Wisconsin adjacent to the Great Lakes, and the Pacific slope west of the Cascade mountains.

The disease is by no means now confined to North America. The orchards of Japan began to suffer in 1911. A severe epidemic developed in New Zealand in 1919, and in 1925 the disease was located in Italy.

Symptoms:

The disease may manifest itself in many ways which are somewhat related. Only one type of the more destructive forms of the disease may be in evidence at one time, though often more than one type of infection may be found. Blos-

soms, leaves, twigs, branches, main trunk of the tree, or the fruit may be attacked, at each stage of the infection definite symptoms being shown. A discussion of the different types of infection and the predisposing factors is now in order.

"Hold-over" cankers are more or less localized infections on the larger branches and the trunk of the host. The areas killed by the bacterial organism vary considerably in extent according to the variety of the host and the age of the canker. Each canker is fairly definite in outline, usually consisting of an irregularly oval, slightly sunken, reddish-brown, rough patch on the bark of a tree, sometimes cracked at the margin of the lesion. The canker has been thought to harbour the infecting organism, but more recent investigations have shown that the virulent organism probably does not hibernate in the dead tissue, but in the living tissue immediately surrounding the canker, especially when the canker is not delimited by a crack. Occasionally, a secondary infection of the diseased tissue by the fungus *Sphaeropsis malorum* may take place, when the rapid growth of its mycelium, with the subsequent production of numerous pycnidia on the surface of the canker, may mask its true appearance and then it may be mistaken for a "Black rot" canker.

In the spring, cankers which are active begin to form the unmistakable "exudate" which is so necessary for widespread summer infection. Droplets of yellowish fluid are forced out from the margins of the active cankers during the warm days of spring and summer, especially after a rain. The exudate then turns brown and is dispersed by insects and rain to other parts of the host. At the same time the organism penetrates the living tissue, adjacent to the canker, at a rapid rate, up to the incredible maximum of eleven inches per day (29). The diseased tissue at first becomes "water-soaked", and a short time after begins to turn brown. Cankers of this sort may enlarge from year to year, but many of the smaller cankers may become isolated in the bark by the production of a protective layer of cork cells around the diseased area. It is therefore evident that older tissues are less susceptible to infection than young tissues, for in the latter the causal organism has an ideal opportunity for growth, whereas in the former there is a certain amount of protection already provided, rendering the spread of the canker more difficult.

In most of the active cankers the organism has been found in the parenchymatous tissue outside of the cambium layer, but after heavy infection or in very susceptible hosts the organism can often be found in the young wood next to the cambium layer. The external type of infection is more common.

Flowers may become infected in several ways. For a long time the belief was that insects were the prime factor in floral infection. This conception has been disputed considerably, and now, after more recent and adequate data having been presented, it is known that meteoric water, in the form of rain or heavy dew, may be the predominant cause of floral infection. The researches of Gossard and Walton (8) and Miller (17) have clearly demonstrated that

insects are not necessary in procuring abundant floral infection. Rain, dripping down from the upper branches to the lower, may carry with it some bacterial exudate from active cankers on upper portions of the tree, or from flowers previously infected. The contaminated water is almost certain to reach some opened flowers on the host, and as infection may take place through the stomata on the outer floral enveloppes as well as through the open flowers, an abundant infection is the result.

Another means of infection is the spread of the disease from a canker near the flowering spurs to the flowers in which case the whole flower cluster is killed. Local infections upon a single flower in a cluster may also spread to adjacent flowers by invasion of the connecting tissues.

Infected flowers wilt and turn brown, but remain attached to the spur. Usually from such floral infection the organism may spread to a branch bearing the flowers, in which case a small canker, or sometimes a potential hold-over canker, is developed.

Insects play a prominent part in the spread of fire blight during the blossoming period. Bees, both wild and domestic, as well as other insects which visit flowers may spread the disease from flower to flower and from tree to tree. This appears to be the most plausible method in the spread fo floral infection rapidly throughout an orchard, especially where the trees are free from cankers but when some infected wild hosts of the pathogenic organism are present in the neighbourhood. The organism has been found capable of causing floral infection after remaining for several days in flower nectar, and for many hours in honey collected by bees from infected trees. Therefore it is not necessary for all bees to become contaminated by visits to infected blossoms in order to spread the disease, but due to contact with honey left by some infected bee in the honeycomb many bees in a hive may become carriers of the organism. Therefore a single bee may be directly responsible for widespread floral infection. The investigations of Gossard and Walton (8) have amply proven that bees, as well as other insects, may become an important factor in the dissemination of fire blight.

Twig infections arise mainly from two sources. Bacteria spread from droplets of exudate on hold over cankers by means of rain during the growing season find a very suitable habitat in the rapidly growing twigs so profusely produced in the spring on branches of the host. Such twigs are very succulent and are well provided with unprotected tissues. Very frequently stomata are entered by fire blight bacteria, so that afterwards the spread of the disease is rapid. Diseased twigs wilt, the tips bend down, and the whole infected portion finally turns brown and dries. Leaves remain attached to the diseased twig, so that the whole presents a very characteristic symptom of twig blight. Apple leaves turn brown, but pear leaves become blackened.

Insects, either sucking or biting insects, likewise provide means of twig infection. Rapidly growing twigs, especially "suckers" or "water shoots", are usually inhabited by some of the above mentioned insects, and it is through

their migrations from diseased to healthy twigs that the disease is spread. Contamination of the insect bodies by direct contact with the bacterial exudate, and the contamination of insect probosces by penetration into newly infected twigs appear to be the main sources of this insect inoculum.

Indirect infection of twigs may arise through the spread of the disease from the flower pedicel or fruit spur into the twig. This is a common occurrence during seasons of heavy floral infection, but in the majority of cases infection of twigs is directly brought about by the above mentioned insects and rain.

Leaves are usually infected directly with very characteristic results. Leaf lesions are generally marginal, either lateral or terminal, but occasionally a few lesions may appear on central portions of the leaf. Infected areas are reddish-brown, more or less zonate, usually darker in the pear than in the apple, and may be roughly triangular. The disease soon kills the entire leaf, after which it spreads down the petiole into the twig. Droplets of exudate are formed on the outside of the lesions during moist weather.

Rain is the main factor bringing about leaf infection. The pathogenic organism is washed down from diseased portions of the host and remains suspended in water droplets which are attached to the margins of leaves for some time. By this means active bacteria rapidly come into contact with the leaf surface and soon establish intimate relationships with the host. A necrotic lesion appears, growing rapidly until the whole leaf may become involved.

Infection of the leaf any also proceed in the reverse order. From a diseased twig or spur the pathogen may migrate through the petiole into the leaf, but usually the entire leaf is killed as soon as the petiole is invaded, in which case the left wilts, and turns brown.

Fruit infection is relatively uncommon in apples. During floral infection the receptacle of the flower becomes invaded and the young fruit is destroyed before it has a chance to develop. In mature fruit infection is relatively uncommon. Pear fruit may become directly infected, usually by biting insects, when a water-soaked spot appears on the fruit. This diseased area spreads rapidly, the centre turns reddish-brown, becomes slightly sunken, and at the same time secretes a honey-colored exudate which turns brown and during dry weather may remain attached to the surface of the lesion as a blackish crust. In pears the whole fruit usually is destroyed, while in apples the infection may be confined to a restricted area.

The results of infection may be summed up as follows:

1. Loss of foliage.
2. Blighting of blossoms and failure to set fruit.
3. Spotting of fruit.
4. Dieback of twigs and branches.
5. Lowered vitality and poor growth due to partial girdling of branches.
6. Death of the entire tree from girdling collar blight.
7. Losses due to necessary pruning.

Many factors are involved in the establishment of the different types of injury. These have already been discussed briefly. Climate and numbers of insects play the greatest part. Through their agency injury to trees and fruit through fire blight may reach serious proportions. This injury may be slight if the average loss through a number of years is taken into consideration, but occasionally the entire fruit crop may be ruined by blossom blight. There may be a few trees which survive a severe attack, but usually the effects last for a number of years. Sometimes, especially when the host variety is very susceptible, the damage may be permanent and the tree may be crippled or killed outright.

Pathologic Anatomy

Though the specific name of this organism, *Erwinia amylovora*, describes it as starch consuming, it does not appear that all the damage for which it is responsible is due to this faculty. It is not an efficient producer of enzymes capable of dissolving plant tissues wholesale as do some of its bacterial relatives. The changes involved during the progress of the disease appear to be largely physical at first, but after the death of the tissues many chemical changes take place.

There has been a good deal of controversy among plant pathologists regarding the method by which tissues are invaded and killed. Earlier workers believed that the host cells were killed by direct enzymatic action or by the infusion of toxic substances produced by the invading organism. Studies of the dead host tissue show that dead cells are apparently plasmolyzed, and contain a thick, brown, amorphous material. It is known that bacteria are present in great numbers in the intercellular spaces of the diseased host, from which they occasionally penetrate into the parenchyma cells, including the sieve tubes, or, in a few cases, into the more resistant vascular elements. In the twigs the bacteria are most abundant in the cortical parenchyma, but they may also invade the cambium. In general, it seems that the principal migration of the bacteria is thorugh the intercellular spaces. In active cankers these bacteria may progress very rapidly, and are often found a considerable distance in advance of the discolored tissue. The bacteria multiply enormously in the intercellular spaces, forcing the cells apart by mechanical pressure. This eventually results in the formation of pockets filled with bacteria. Occasionally some of the plasmolyzed cells may be ruptured by external pressure, in which case bacteria may be observed within the cells. The ruptures of the cell walls indicate that a break of the wall has occurred but that no visible dissolution took place.

During periods of activity bacteria may rupture the diseased tissue, in which case the bacterial mass, mixed with cell sap, comes to the surface of the lesion as the well known exudate. The change in color of this liquid exudate is probably due to the presence of some oxidizing enzymes causing the almost

colorless liquid to turn brown or black soon after it is exposed to air, and which likewise changes the color of the diseased tissue.

Host Relationships and Varietal Susceptibility

The organism whose activities have been described appears to be somewhat omnivorous. The number of hosts which may be attacked is very large and diverse in character, but most of them belong to the order Rosales. Within these limits individual genera and species show noticeable differences in the amount and intensity of infection. While these differences may be due to internal physiologic variation of the host, yet the many possible predisposing factors should not be left unconsidered. These predisposing factors are enumerated and briefly described as follows:

1. Age of tissues— The study of infected tissues shows that the pathogenic organism confines its activities to the actively developing regions of the host. In young tissues, such as leaves, flower, buds, flowers, twigs, including abnormal formations such as "water shoots" and "suckers", the active tissue is not protected sufficiently on the surface to prevent the entry of the pathogene. Therefore in these plant parts a small injury may provide an open avenue for the entry of the parasite. Other wounds, even in older tissue, will similarly enable the bacterium to enter. Therefore we find that primary stages of the disease commence in the young and most exposed parts of the plant, and from these points the disease spreads to the older and more protected parts of the plant through the spongy parenchymatous tissue beneath the corky layers of the bark.

2. Cultivation—Any procedure which will cause increased production of young tissues mentioned above will foster the development of the disease or increase the opportunities for such development. Continued cultivation of the orchard, super-abundant moisture, excess fertilizer, and some other factors all increase the production of supernumerary young twigs which may be a factor in the introduction of the disease to the host. Fire blight finds such twigs a very suitable habitat, and as these twigs are also generally occupied by aphids the chances for infection become greater. Furthermore, many of these twigs grow from the main trunk of the tree or from its base, so that if the disease should develop in such twigs there is grave danger that the tree may be eventually girdled by a canker originating from the diseased shoot.

3. Number of insect carriers During the blossoming period of the host insects play a notable part in the dissemination of the pathogen. Though rain has largely taken away from insects the credit of transporting the disease yet it is credible that insects play a large part in causing infection of flowers during that critical period. With a decrease in the number of insects there should be a corresponding decrease in the percentage of blossoms infected.

4. Number of "hold-over" cankers—It is obvious that this factor is important. Initial infections of a tree originate from such cankers on a tree, or such

infections may originate from similar cankers of other trees close by. Whether the organism is disseminated by insects or rain the initial source of infection is the canker.

5. Wounds—Hailstorms have been found to be a predisposing factor in the case of fire blight. The organism enters the host through openings of some kind, and driven hailstones are capable of causing considerable damage of this nature, not only in the younger parts of the tree but also in branches two or three years of age. As hailstorms are usually followed by rain it is obvious that if there is any disease on the tree at the time the spores or the bacteria will be washed into the wounds. This usually leads to a general infection.

It is well to note here that wounds caused by bark borers are also avenues of infection for the fire blight organism, in many cases causing a destructive collar blight.

It may be said that, in general, any condition which favours a more succulent and rapid type of growth render the host more susceptible to the ravages of fire blight. Under such conditions infections are likely to occur and the advance of the lesions will be more rapid and will continue longer without being checked. Prolonged hot and dry weather is unfavourable for blight, retarding dissemination and increasing the resistance of the tissue, while abundent rainfall, followed by warm, cloudy weather is favourable since infection is more likely, for the tissues are filled with cell sap and are easily invaded. Blossom blight will not be produced unless there are active blight centres producing exudate which can be disseminated when the flowers are in a susceptible state. Pears, west of the Cascade mountains in Washington, escape blossom blight because they generally come into bloom before the hold over cankers have become active, but exudate is produced in time to start an epidemic of blossom blight in apples.

Though fire blight has been originally described from the pear, more recent investigations have shown that the host range may be much more extensive. Practically all our cultivated apples and pears are susceptible to the disease when grown under conditions favourable for the development and the dissemination of this malady. There is some difference of opinion regarding varietal susceptibility but this appears to be a factor too much influenced by local conditions to enable anyone to make a general or definite statement regarding the degree of susceptibility of any variety.

The following plants have been reported as hosts of the fire blight organism: pear, apple, quince, wild and cultivated crab apples, service berry, hawthorn, California holly, mountain ash, apricot, yakimine, cheney plums, prunes, cherries loquat, strawberries, and in one case, Lombardy poplar, though in the last instance there is some doubt regarding the veracity of the report.

From data obtained from many widely separated sources the following table, listing some varieties of pears and apples with regard to their susceptibility to fire blight, has been compiled.

Table 1.—The comparative susceptibility of some varieties of apple and pear to fire blight.

Host	Very susceptible	Susceptible	Resistant
Pear	Bartlett	Flemish Beauty	Kiefer.
	Howell		Seckel.
	Clapp's Favourite		Winter Nelis.
			Oriental varieties.
Apple	Yellow Transparent	Fameuse	Ben Davis.
	Jonathan	McIntosh	Ontario.
	Wealthy	Dudley	Early Harvest.
	Hyslop	Tolman Sweet	Gano.
	McMahon	Gravenstein	Spy.
	Ingram	Alexander	Duchess.
Crab-apple	Transcendant.		
	Spitzenberg.		

No hard and fast rules can be drawn regarding the susceptibility of the host. The disease manifests itself in many ways, and as these manifestations are not always the same for all varieties an estimate of the susceptibility of a variety can be made only by a careful study of the infection, the special conditions which are responsible, and after, an evaluation of the parts affected. Some varieties abound in hold-over cankers, others are more susceptible to twig infections, while blossom blight may be most destructive in a third group, so the relative values of the parts infected and the ease with which the disease appears must be considered.

Mode of Infection

The inoculum which is used to procure infection can be said to occur in two forms or stages, the primary and the secondary. Both of these are destructive, but the primary inoculum usually produces blossom infection, while the secondary inoculum is responsible for most of the infections appearing on leaves, twigs, and fruit.

The primary inoculum establishes the fire blight organism in the current year's growth. Obviously the factors considered are important, so they are discussed briefly in the following paragraphs.

Early experiments have demonstrated that bees and other pollinating insects may carry the infection from blossom to blossom. Until recently no

definite statement could be made regarding the primary infection in a flower, but now it is known that meteoric water is the cause. Many insects were, however, found capable of transporting the infection over the host. A list of these is given in Table II.

It is probable that other insects besides the ones listed are capable of transmitting fire blight from host to host. Any insect which finds a suitable habitat, permanent or temporary, on a host of the fire blight organism becomes automatically a potential carrier of this disease. The majority of insects, however, appear to play a secondary part in the transmission of the disease, as rain now seems to be the prime factor.

Meteoric water, in the form of rain or heavy dew, may become the most important factor in fire blight spread if the proper conditions, including the necessary predisposing factors are present. The initial infections appear, in almost every case, to be due to bacterial infections originated through the washing down of bacteria from hold-over cankers. This is readily supported by the

Table II.—Insects concerned in fire blight transmission.

Insect	Reported	
	Where	By whom
Bees Wasps Flies (?)	Washington, D. C.	Waite, M. B.
Green apple aphis	Montana	Swingle, D. B.
Bark Borers	Ontario	Jones, D. H.
Tarnished plant bug	New York state	Stewart, V. B.
Apple tree borers	Pennsylvania	Orton, C. R. and Adams, J. F.
Click beetles Ants	California	Jones, B. J.
Aphis avenae Empoasca mali	Wisconsin	Burrill, A. C.

presence of conical areas of infection on trees, the apex located at an active canker, and the base the lowest branch of the tree exposed to the bacterial wash. In many such instances insects being few in number could not have been responsible for the extensive damage observed, so that the only explanation appears to be the one given above. As the pathogenic bacteria can penetrate into the host tissues by means of the stomata it is not necessary for insects to be present in order that the disease may be widely disseminated. Infection, of course, is facilitated should the host within the zone of infection become wounded in any way, e.g. hailstones, exposed cuts, etc. The classic experiments of Gossard and Walton (8) and Miller (17) produce enough evidence to thoroughly support this theory. Additional weight to the theory that primary infections are largely caused by meteoric water was given by the discovery that there exists a singular correlation between the number of hold-over cankers and the amount of blossom infection. Many flowers were shown to be infected prior to opening, so that no insect which customarily visits open flowers could have come into contact with it, since such insects do not visit unopened flowers as a rule. The only explanation was afforded by meteoric water being regarded as the source of the infection.

Man plays no mean part in the spread as well as in the control of fire blight. His main contribution to epidemic infection appears to be the tendency towards carelessness in disinfecting tools and wounds when pruning, and thereby spreading the disease and causing new cankers to form. In relation to this point it may be said that birds also have been known to be carriers of this disease, as well as some tree-climbing animals.

The agencies responsible for the spread of the primary inoculum likewise function during the distribution of later or secondary inoculum. During former years insects were considered to be the chief factor in the latter case, but gradually with the more advanced researches on the disease other factors came into prominence, and now we know that meteoric water as an agent of distribution of the secondary inoculum is on a par with insects. However, here, contrary to the conditions found in the distribution of the primary inoculum, insects are still known to be responsible for a large proportion of the infections. Their importance varies with the season. In certain years or seasons the number of insects inhabiting the fire blight host may be small, in such cases meteoric water being the predominant factor; in other years, though insects may be many, the inoculum is lacking, or thirdly, during wet years the infections caused by insects is over- -shadowed by water carried infections. Pollinating insects, of course, do not play an important part in transmitting the secondary inoculum, but sucking or biting insects, or wood borers, are responsible for the dispersal of the secondary inoculum. Many other factors may influence the proportion of insect-carried infections, but the majority of them play a very small part, needing little or no description.

Control

Fire blight has become so very important that a great deal of research has been carried on in an attempt to discover suitable methods and materials for the control of this disease. It is one of the most difficult to combat of all the diseases of pomaceous fruits. The control measures are usually very severe and are not always considered practical, but with differences of conditions some of them, at least, may be found useful. They are listed and described below.

1. Eradication of cankers--Hold over cankers are the source of primary inoculum, and even though many of them may not become active, nevertheless it is a wise precaution to remove as many as possible from the trees, and to burn the pruned branches. Small cankers involving twigs, dead fruit-spurs, and smaller branches should be removed entirely; but when a canker has developed on a larger limb and has not yet girdled more than half the branch it is recommended that the surface of the canker be scraped as far as the disease reaches into the bark. Some of the tissue surrounding the canker should also be removed. The disease does not readily penetrate into the wood and hence scraping will remove nearly all the infected tissue. The cambium layer, at the junction of the wood and the bark, should be left as intact as possible. The scraped canker can than be painted over with a disinfectant for which the formula is given below Cankers should be scraped during late autumn or early spring when their activity has ceased. The removal of diseased twigs and cankers should be performed prior to the regular spring pruning, for there will be less danger of spreading the disease through careless handling of the pruning tools.

2. Control of insect carriers---Unfortunately some of the most dangerous of blight carriers are useful to mankind. In attempting the control of fire blight it is necessary to select a proper method of insect control in order not to harm pollinating insects and honey-producing bees. If one remembers that danger of early infection is considerably diminished if most of the active cankers on trees or neighbouring wild hosts are removed, no loss to bees need be suffered by the application of poisonous sprays during or shortly before the blossoming period. After this critical period is past, bees are not considered in the application of insecticidal sprays which may then be applied freely. Contact or stomach poisons may be applied for sucking and biting insects respectively. Often insect repellants are used in sprays, but if these are efficient there is some danger of loss of fruit due to insufficient pollination of flowers.

3. Modification of cultural conditions---The various predisposing factors have been discussed earlier in this paper. Some of the most important were excessive cultivation, excessive pruning, and excessive application of nitrogenous fertilizers. All of these conditions tend to increase the production of susceptible tissues in the form of water shoots and suckers. Such new growths are readily-infected in various ways and are always a source of danger to the orchard. Judicious handling of the orchard will prevent these supernumerary growths and in consequence reduce the severity of the disease.

4. Blossom spray—If infection appears and the probabilities are that the disease will spread to other blossoms, spraying the trees with weak Bordeaux mixture is recommended. The strength used is 1-3-50, the lime being slaked prior to mixing. Such spray is applied when the trees are in bloom, and though there is some danger to bees, the danger is not great. Sufficient control of blossom blight is obtained to warrant the use of this spray, though sometimes it appears that efficient control of the disease is not secured. In the latter case it seems that uneven opening of blooms is a factor, since all blooms opening after the spray has been applied are not protected by the spray.

5. Resistant varieties—A list of apples and pears has been given in Table I. It is seen that there is a considerable variation in the susceptibility of different varieties to fire blight. It is obvious, therefore, that the use of these resistant varieties will materially decrease the amount of the disease in an orchard.

6. Removal of wild hosts—It is important that none of the more susceptible wild hosts are in close proximity of the orchard. If this is unavoidable, they should be watched and the disease, should it appear, be checked on them before it provides inoculum for general infection. Eradication of these wild hosts is the safest precaution.

Disinfectants

(1) Mercury-Glycerine disinfectant (Day)

1 quart distilled water (or rain water)
3 quarts commercial glycerine
16 tablets cyanide of mercury (¼ oz. of crystals)
16 tablets bichloride of mercury (¼ oz. of crystals).

Add water to glycerine. Heat to almost boiling in a clean enameled kettle. Dissolve chemicals, stirring rapidly. This is placed in stoppered bottles and applied to cuts with a brush. *This is very poisonous to animals and humans.*

(2) Bordeaux Oil Paint (Day).

Mix any of the prepared, dry mixed, commercial forms of Bordeaux dust with sufficient raw linseed oil to form a thick paint. It will become thinner on standing. It is applied to large cuts with a brush and will stay on for at least four years, giving plenty of protection against wood rotting fungi.

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OBSERVATIONS ON THE ASCOSPORE DISCHARGE OF VENTURIA INAEQUALIS, IN RELATION TO CERTAIN ENVIRONMENTAL FACTORS

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During the past seven years, while conducting spraying experiments to control scab disease of apples, observations were made on the periods of ascospore discharge. These data are recorded here along with temperature and precipitation records since there appears to be a striking correlation, over a number of years, between environmental factors, particularly temperature and precipitation, and the discharge of ascospores.

The data as recorded here, were secured from over-wintered leaves of the MacIntosh variety showing abundant perithecial production. These leaves were kept out-of-doors on a gunny sack, to prevent splashing of mud, and held in position by nails. Above the leaves were placed microscope slides smeared with vaseline. These slides were changed and examined after every period of rainfall from the time that ascospores were seen to be mature until no further discharge was noted. The relative amount of discharge occurring was noted as being light, medium or heavy. The ascospores were generally found adhering to the slides in clumps and the frequency and size of the clumps provided a means of judging the intensity of discharge.

Table I.—Ascospore Discharge.

1924-1930.

—	1924	1925	1926	1927	1928	1929	1930
Date of initial discharge.....	May 16..	May 1st.	May 19..	May 4th.	Apr. 21..	Apr. 30..	May 1st.
No. of discharges.....	11	11	12	17	14	15	15
Date of first major discharge.	June 6...	May 7th.	May 19..	May 23..	May 17..	Apr. 28..	May 2nd
Date of final discharge.....	June 28..	June 28..	June 26..	June 26..	June 27..	June 25..	June 26..
No. of days in disch. periods.	43	58	38	53	67	66	57

Actual initial discharge not obtained in 1924.

In considering the mean temperatures of the fall months preceding ascospore discharge, in connection with the initial ascospore discharges, a striking correlation is apparent as will be seen from the following table.

Table 2.—Correlation between Temperature and Ascospore Discharge.

Year	October	November	December	Average Mean Temp.	Initial Ascospore Discharge	
					Date	Year
1923.....	47.8	38.2	35.4	40.4	May 16th....	1924
1924.....	52.3	40.8	24.6	39.2	May 1st.....	1925
1925.....	44.0	38.4	27.4	36.6	May 19th....	1926
1926.....	50.5	39.8	25.3	38.5	May 4th.....	1927
1927.....	55.1	44.3	30.1	43.4	Apr. 21.....	1928
1928.....	53.8	41.3	34.1	43.0	Apr. 20.....	1929
1929.....	50.3	38.4	26.8	38.5	May 1st.....	1930

Actual initial discharge not obtained in 1924.

NOTE:—Ascospore discharge in any year is to be compared with the temperature of the fall months preceding, that is, the discharge of 1925 is dependent upon the fall temperatures of 1924.

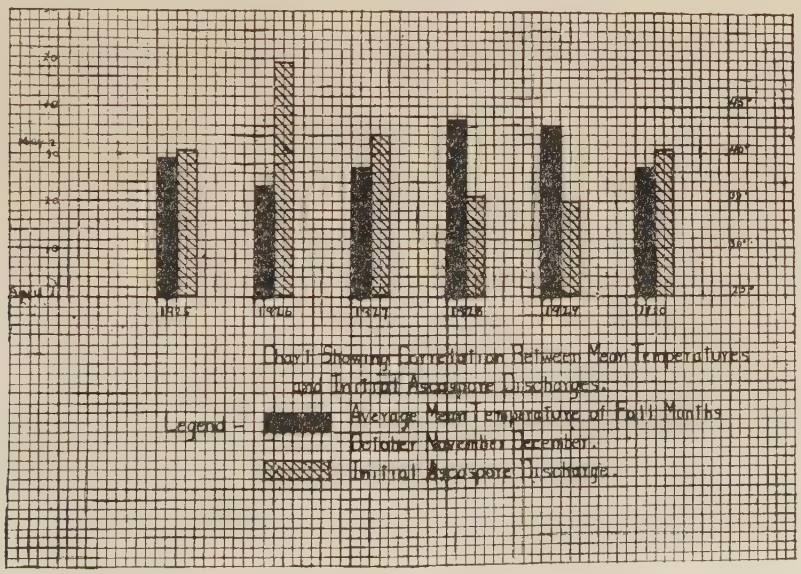


Figure 1.—When the mean temperature of the winter months, January, February and March are considered, no such correlation is apparent as can be seen from Table 3 below.

From the above table it is apparent that there exists a correlation between the mean temperature of the fall months and the date of initial ascospore discharge the following spring. For instance in both 1928 and 1929, initial ascospore discharge took place on April 21st and April 20th respectively and the average mean temperature for the fall months preceding was 43.4 and 43.0 respectively. In other words, the highest fall temperatures were in 1927 and 1928 and these temperatures were followed in turn, by the earliest ascospore discharges. Conversely the lowest fall temperature was experienced in 1925, namely 36.6, which was followed by the latest ascospore discharge, namely, May 19th. This points out a striking correlation which may be found to be of some value from the standpoint of control. The following chart shows this correlation very clearly.

Table 3.—Correlation between Temperature and Ascospore Discharge.

Year	January	February	March	Average Mean Temp.	Initial Ascospore discharge	
					Date	Year
1924.....	21.0	19.4	30.2	23.5	May 16th....	1924
1925.....	21.5	28.6	36.2	28.7	May 1st.....	1925
1926.....	25.0	22.9	23.6	23.8	May 11th....	1926
1927.....	24.4	29.7	37.1	30.4	May 4th.....	1927
1928.....	26.6	26.4	31.9	28.3	Apr. 21.....	1928
1929.....	24.0	22.6	37.9	28.1	Apr. 20.....	1929
1930.....	24.3	28.7	32.3	28.4	May 1st.....	1930

Actual initial discharge not obtained in 1924.

There does not appear to be any correlation here between the winter months of January, February and March and time of ascospore discharge. In this respect, our records do not bear out the contention of Howitt & Evans (1), who say "The mean temperature of the winter months, especially of January, February and March has a marked influence upon ascospore development and primary discharge in the spring in *Venturia inaequalis*."

However when the mean temperature for the six months preceding ascospore discharge is compared as above the same correlation is apparent as when the fall months (October, November and December) alone are compared.

The following table brings this out clearly. Howitt & Evans (1) also found a correlation between this six months period and time of initial discharge.

Table 4.—Correlation between Temperature and Ascospore Discharge.

Mean Temperature	1923	1924	1925	1926	1927	1928	1929
October	47.8	52.3	44.0	50.5	55.1	53.8	50.3
November	38.2	40.8	38.4	39.8	44.3	41.3	38.4
December	35.4	24.6	27.4	25.3	31.0	34.1	26.8
January	21.0	21.5	25.0	24.4	26.6	24.0	24.3
February	19.4	28.6	22.9	29.7	26.4	22.6	28.7
March	30.2	36.2	23.6	37.1	31.9	37.9	32.3
Average Mean temp. for Oct., Nov., Dec., Jan., Feb. and March	32.0	34.0	30.2	34.5	35.8	35.6	33.4
Date of initial discharge following spring	May 16*	May 1...	May 19..	May 4...	Apr. 21..	Apr. 20..	May 1...

* Actual initial discharge not obtained in 1924.

From the above it would appear that the temperatures of the fall months play a more important part in connection with ascospore discharge than do the temperatures of the winter months, January, February and March. This is borne out by the fact that although the six months period (October, November, December, January, February and March) shows a correlation as noted above, there is no such correlation with the winter months (January, February and March) whereas there is a definite correlation between the temperature of the fall months (October, November and December) and ascospore discharge. This correlation for the fall months is identical with that for the six months period. It would therefore appear as though fall months were the more important in influencing the date of initial ascospore discharge.

Undoubtedly precipitation is an important factor in perithecial production. Records for the past seven years show that ascospore discharge in Ontario is directly associated with periods of rainfall. It would appear from our observations as though the temperature of the fall months plays its part in the early stages of perithecial production and then as maturity approaches, precipitation

(1) Howitt, J. E. and Evans, W. G., Preliminary report of some observations on Ascospore Discharge and Dispersal of Conidia of Venturia inaequalis (Cooke) Wint. Phytopathology, Vol. XVI, August, 1926.

is the all-important factor related to actual discharge periods. This is brought out to some extent at least by a comparison of the following tables:

Table 5.—Precipitation, October, November and December.

—	1923	1924	1925	1926	1927	1928	1929
Precipitation, Rain, Oct., Nov., Dec.	—	2.31	6.15	7.28	9.33	7.60	5.50
Precipitation, Snow, Oct., Nov., Dec.	—	8.75	8.00	13.50	2.50	2.00	24.25
Total as rain	8.92	3.185	6.95	8.630	9.58	7.80	7.925
Date of following spring discharge	May 16*	May 1...	May 19..	May 4...	Apr. 21..	Apr. 20..	May 1st.

* Actual initial discharge not obtained in 1924.

A study of this table does not bring out any definite correlation between rainfall and ascospore discharge. On the other hand a study of the precipitation for the winter months in comparison with dates of initial ascospore discharge suggests a definite correlation. This is brought out in the following table:

Table 6.—Precipitation, January, February and March.

—	1924	1925	1926	1927	1928	1929	1930
Inches of precipitation, rain..	—	4.58	2.63	4.69	4.72	5.64	6.97
Inches of precipitation, snow.	—	21.75	24.25	19.25	27.50	24.50	30.75
Total as rain 1 inch snow—1-10th inch rain	7.87	6.755	5.055	6.615	7.470	8.090	10.045
Ascospore discharge	May 16..	May 1...	May 19..	May 4...	Apr. 21..	Apr. 20..	May 1...

Actual initial discharge not obtained in 1924.

From the above table a correlation between amount of precipitation occurring in the winter months and the date of initial discharge holds true with the exception of 1930. In this period the precipitation was unusually heavy, particularly the snow-fall. It could be expected therefore that discharge would have occurred earlier if increased precipitation brought about earlier discharge. An explanation of this failure of earlier discharge may be seen in the following table:

Table 7.—Showing Relation of Maturity of Perithecia to Date of Initial Discharge.

Year	Date when perithecia contained mature spores	Date of Initial Discharge	Inches of rainfall in month of April
1924	May 14	May 16 *	3.13
1925	———	May 1	1.04
1926	May 10	May 19	3.15
1927	Apr. 30	May 4	1.05
1928	Apr. 16	Apr. 21	2.21
1929	Apr. 18	Apr. 20	5.38
1930	Apr. 5	May 1	.84

* Actual initial discharge not obtained in 1924.

An examination of the perithecia in the spring of 1930 revealed the ascospores to be partially mature on April 5th. The unusually light precipitation during April resulted in unfavourable conditions for discharge of these spores

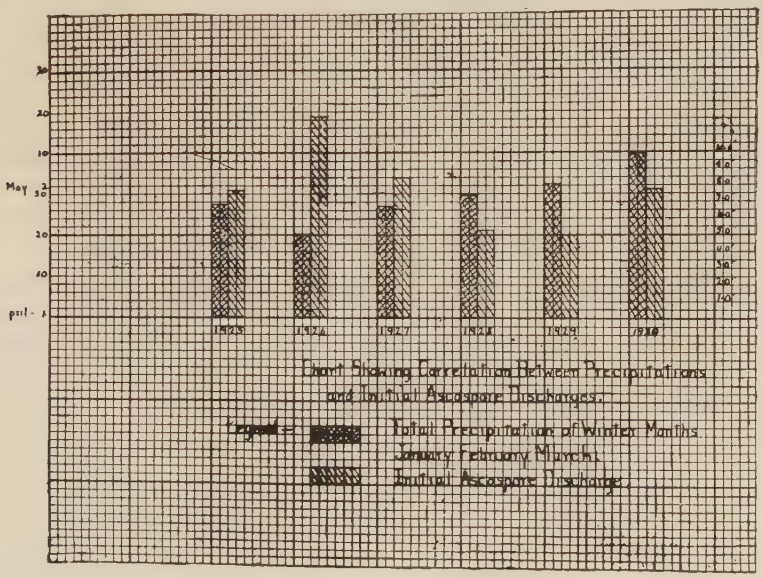


Figure 2.—Chart showing Correlation between Precipitations and Initial Ascospore Discharges.

that were mature. On May 1st a fair discharge of spores followed a light precipitation of .09 inches. It is thought that if the precipitation during April had been of an average amount, discharge would have occurred considerably earlier. Moist chamber tests of the leaves for discharge set up on April 5th showed general discharge occuring on April 10th. It would appear therefore that precipitation at the time the perithecia are approaching maturity is very important in relation to initial discharge.

In comparing the rainfall for the six months as was done for temperature, there does not appear to be any constant correlation between precipitation and ascospore discharge. Following the same reasoning here, as was outlined above for temperature, it follows that the precipitation of January, February and March has a more direct connection with ascospore discharge than has the precipitation of October, November and December. It therefore follows from the above that a fairly definite correlation can be shown between the mean temperature of October, November and December and ascospore discharge on the one hand and between precipitation during January, February and March and ascospore discharge, on the other.

In explanation, it might well be that temperature is the more important factor in the early stages of perithecial formation and differentiation but once the final stages of maturity are approached, moisture may then become of greater importance. It is definitely known for instance, that the actual discharges in the spring depend upon precipitation. This is clearly shown by Fig. 3 which gives the ascospore discharges for the years 1925 to 1930 as related to precipitation. It is to be noted that in every case discharge takes place during a period of precipitation.

Some instances have been noted where rainfall took place with no ascospore discharge resulting. In these cases the perithecia were likely temporarily exhausted of mature ascospores and hence no discharge. There is no direct correlation between amount of rainfall and intensity of discharge. Heavy discharges sometimes follow light rainfalls, and conversely, light discharge sometimes follows heavy rainfalls. Sufficient rainfall to thoroughly wet the leaves appears to be all that is necessary to cause discharge. See Figure 3.

It has been suggested that temperature at the time of precipitation may have an influence on the discharge of ascospores and the intensity of such discharge. Although no records have been kept of the temperature at the actual time of discharge, heavy discharges have been noted to occur when the temperatures for the 24 hour period have been as follows:

May 7th, '25	Maximum 52°	Minimum 31°	Mean 41.5°
June 12th,, '26	Maximum 76°	Minimum 57°	Mean 66.5°

Light discharges have been recorded under the following temperatures:

Apr. 21st, '28	Maximum 44°	Minimum 29°	Mean 36.5°
June 25th, '27	Maximum 79°	Minimum 55°	Mean 67.0°

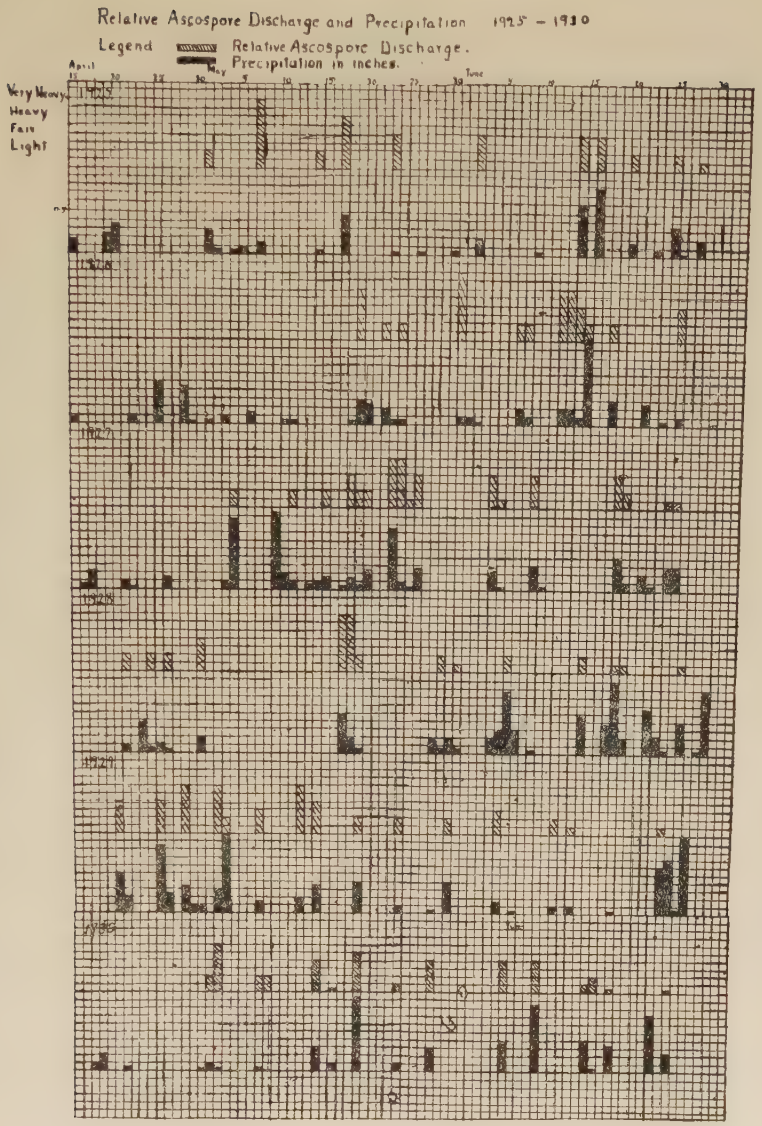


Figure 3.—Chart showing relationship of ascospore discharge to precipitation.

There is a great variation in the number and intensity of discharges. Some years the major discharges are early, while in other years they are greatly delayed. This was quite marked in 1924 when the heaviest discharge occurred on June 13th, just 4 days after the calyx stage of the host. In 1929 the period of major discharge occurred shortly after the host was in the delayed dormant stage. When the period of major discharge occurs early in the development of the host, the control of scab is more difficult.

In this connection it is interesting to note that in those seasons of greater rainfall (January, February and March) the major ascospore discharges tend in most cases to take place earlier than in seasons of less rainfall. The following table points this out. The year 1928 is, however, an exception.

Table 8.—Rainfall data, Initial and Major Discharge Periods.

—	1925	1926	1927	1928	1929	1930
Rainfall, Jan., Feb., Mar.	6.755	5.055	6.615	7.470	8.090	10.045
Date of Initial Ascospore discharge	May 1...	May 19..	May 4...	Apr. 21..	Apr. 20..	May 1...
Date of Major discharge	May 7...	May 31..	May 23..	May 17..	Apr. 28..	May 2...

The year with the earliest major discharge was 1929, with a recorded precipitation (January, February and March) of 8.090 inches. In 1930 the precipitation was heavier but the date of major discharge was four days later. In this year the lack of rain during April delayed the discharge. The date of the major discharge May 2nd was one day later than the initial discharge while in 1929 the major discharge took place eight days after initial discharge. If rainfall had occurred earlier in the season of 1930, probably major discharge would have been recorded earlier. In 1926 the season of least rainfall the major discharge was the latest, namely May 31st. In 1925 and 1927 the rainfall was quite comparable, being 6.755 and 6.615 inches and the first major discharge was May 7th and May 23rd respectively. Comparing 1928 with 1925 the major discharge was delayed 10 days even though there was heavier precipitation in 1928. The reason for this delay was that no rain fell from April 30th until May 17th (see Figure 3) hence there was no possibility of ascospore discharge between these dates.If a rainfall had occurred between these dates there would most likely have been a discharge. This suggests that it is unsatisfactory to attempt to correlate the major discharges, or in fact any discharges after the initial discharge, with any precipitation that may take place in January, February or March. With the initial discharge it is different because as our records show, the seasons with highest temperature and greatest rainfall mature their ascospores the earliest and therefore with the first rainfall of late April or early May, discharge will take place.

This is clearly pointed out by the following data. In 1928 the first discharge took place on April 21st, accompanied by rain, of course. However a goodly sized rainfall occurred on April 19th—two days before—but no ascospores were discharged. The spores were evidently immature. It is to be recalled that in this year, 1928, when early ascospore discharge occurred, heavy precipitation took place in January, February and March. Now let us compare with this the condition in 1926 when ascospore discharge was considerably later—May

19th—and less precipitation was experienced in January, February and March. The first ascospore discharge occurred May 19th, just 27 days later than in 1928. Yet in 1926 there were several heavy rainfalls previous to that occurring on May 19th when discharge took place. To be exact, rainfalls were experienced on April 22nd, April 25th, April 28th, April 29th, May 1st, May 3rd, May 6th, May 10th, May 11th and May 18th, yet in no case did discharge take place. Why not? Simply because the spores were not mature. Why were they not mature? Simply because the temperature conditions in October, November and December were not as favourable for perithecial growth as they were in October, November and December in 1928, and in addition the smaller precipitation of January, February and March did not hasten differentiation or maturation of the perithecia to the same extent as the greater precipitation in 1928 did. The result was delay in initial ascospore discharge. The records for the past seven years show that although ascospore discharges always accompany rain periods, it does not follow that all rainfalls are accompanied by discharge. This points out that other factors besides rainfall play a part in ascospore discharge.

In this connection it should be pointed out that although there appears to be a definite correlation between fall (October, November and December) temperature and precipitation (January, February and March) on the one hand and initial ascospore discharge on the other, it would appear that all discharge periods taking place after the initial discharge (including major discharge) are largely dependent upon rainfall at time of discharge.

In comparing the time of initial ascospore discharge of the fungus with the developmental stages of the host, we find the following:

Table 9.—Initial Ascospore Discharge in Relation to Development of Host.

—	Delayed Dormant	Pink	Calyx	Initial Ascospore Discharge
1924	May 8	May 23	June 8	May 16.
1925	Apr. 29	May 16	June 1	May 1.
1926	May 8	May 21	June 4	May 19.
1927	Apr. 19	Apr. 29	May 12	May 4.
1928	Apr. 28	May 12	May 29	Apr. 21.
1929	Apr. 24	May 11	May 28	Apr. 20
1930	Apr. 25	May 2	May 17	May 1st.

Note.—Dates for host development are mean for the period.

Actual initial discharge for 1924 not obtained.

It is apparent from the above that ascospore discharge bears, over a period of years, no direct correlation with the host development. That is, for four years, (1924, 1926, 1927 and 1930) primary ascospore discharge took place anywhere from 6 to 15 days after the middle of the delayed dormant period. In two years, 1928 and 1929 the primary discharge took place 7 to 4 days respectively before the host was in the delayed dormant stage. In 1925 the first discharge practically coincided with the delayed dormant state of the host. From the standpoint of control the most important initial spray in 1925 should have been the delayed dormant; in 1926 the pre-pink, no delayed dormant necessary; in 1927 the pink, no delayed dormant necessary; in 1928 the delayed dormant; in 1929 the delayed dormant and in 1930 the pre-pink. These statements are based entirely on the above records and point out the advisability of basing spray schedules on other than host development alone, i. e., ascospore discharge and precipitation data.

SOME METHODS IN THE STUDY OF PHYSICAL CONDITIONS AFFECTING FOREST INSECTS

By J. J. DeGryse, Entomological Branch, Department of Agriculture, Ottawa, Can.

Introduction

The forest, as a habitat, presents many peculiar features necessitating the adoption of special methods in the study of its insect population. These peculiarities are largerly of a physical nature, resulting ,as they do, from the influence of the forest cover on the climatic conditions to which its insects are subjected. For many years this influence has been the object of extensive investigations by foresters and meteorologists, both in Europe and in America, but it is only in very recent times that any special note of them has been taken by the students of animal life.

Since the importance of climatic influences upon the development and behaviour of insects is now generally recognized, a brief sketch of the principal characteristics of the forest climate and some simple methods of measuring them are given below*.

General Principles

Referring to the temperature of the atmosphere above the tree tops, Fernow (1893) says that "the surface of the forest crown appears meteorologically much like the surface of the meadow or cornfield. It is as if the soil surface has been raised to the height of the trees." The forest cover acts as an obstacle to the various climatic influences and the majority of the characteristics of its climate may be explained on this basis. It is evident that this action will vary not only with the type and composition of the stand, but also, at different seasons and even at different times of the day. Moreover, as Fernow (1893) remarks, "as an organic being the forest may be also an independent source of heat."

In a short paper such as the present one, it would be impossible to give a detailed account of the complicated climatic conditions resulting from the action of the forest, the influence of which is felt not only within but without the forest itself. Be it sufficient to summarize here briefly some of the principal conclusions arrived at by various investigators with regard to the climate inside the forest and to give some very general hints as to methods of procedure.

In general it may be said that the climate of the forest is less subject to variation that that of the open country.

The vertical gradient of temperature obtaining in the open country during the day, is reversed under the crown cover. That is to say, the temperature increases from the ground upward.

* A detailed study of this subject, now in preparation, will be published elsewhere.

Relative humidity decreases upward from the ground and, according to Lorenz Liburnau (1890) is directly proportional to absolute humidity, a condition which is the reverse from that obtaining in the open. Both temperature and relative humidity are more variable in range at the higher levels. The evaporating power of the air increases as the height, its gradient being steepest at the lower levels.

Light intensity in the different types of forests and in their different parts varies greatly, and, whilst of undoubted importance in many respects, constitutes a factor which it is difficult to measure without expensive equipment and considerable experience.

Methods

In the study of physical conditions affecting forest insects, it is advantageous to divide the forest into ecological zones and to take all the important measurements in each of them. Weese (1924) and Blake (1926) established stations at various levels as follows: A.—in the soil, B—in the litter, C—at 60 cm. and D—at 10 or 11 m. In our own experiments these stations were established, A—in the soil, B—in the litter, C—at 1 m., D—at 7 m., E—at 16 m. On the whole the results obtained by us do not differ materially from those of Weese. The table below shows the nature of the records taken for each station.

Station	Temperature	Relative Humidity	Evaporation	Absolute Humidity
Soil	X	.....	.....	X
Litter	X	.....	X	X
1 m	X	X	X	
7 m	X	X	X	
16 m	X	X	X	

For the sake of comparison a set of records was taken in the open covering temperature, relative humidity, precipitation, evaporation, wind direction and velocity, clouds and barometric pressure.

Actual soil temperatures at different depths are obtained most statisfactorily by the use of special soil thermometers of which there are several good types on the market. Blake (1926) exposed maximum and minimum thermometers in a rectangular hole, .4 m. deep, .3 m. long and .2 m. wide, lined with galvanized wire screening and covered with a heavy grating which in turn was covered with debris. A small hole in this grating covered with a piece of bark gave access to the instruments. Toumey and Stickle (1925) and later Tsi-Tung Li (1926) dug

soil wells with holes bored at the desired depths in the side wall into which thermometers mounted on special wooden devices were inserted. This latter method is probably the most satisfactory. Continuous records are obtained by means of good long-distance thermographs with the sensitive elements buried at the required depths.

When maximum and minimum thermometers are used for measuring air temperatures, at least three daily readings of actual temperatures are necessary to obtain a fair daily average. Actual readings are taken either on the minimum thermometer or preferably on a special standard thermometer placed in the shelter with the maximum and minimum thermometers. Records obtained by means of good thermographs, properly checked with standard thermometers, are the most desirable. When checking self recording instruments with standard thermometers, it should be remembered that there is always more or less lagging in the self recording instrument and that the record made by it is rather an average for short periods than an actual reading. In making corrections it is best to use the mean of several readings taken at brief intervals on the mercurial thermometer. It is a recognized fact that especially on calm days there may be differences of temperature in different parts of louvred shelters (Stevenson screens). Since the circulation of air in the forest is considerably reduced by the windbreak effect of the trees, temperatures registered inside of standard screens may often be more or less misleading.

Relative humidity is ascertained by means of sling psychrometers, dry and wet bulb thermometers or self recording hair hygrometers. The first method gives the most exact measure and its readings are used in correcting hair hygrometers. The sling or whirling hygrometer is a delicate instrument and unless it is used in accordance with standard specifications it may give very unreliable results. The directions given in Dr. Marvin's introduction to his psychrometric tables (1912) should be closely adhered to. Among other things, the material used for covering the wet bulb is of considerable importance. Sometimes wicks furnished by manufacturers of otherwise excellent instruments have been found to be unsatisfactory. The following table shows a series of readings obtained by my assistant, Mr. L. Roy Finlayson, with two different makes of instruments A and B. The wet bulb of A was fitted with a cover made according to standard specifications, B with a wick furnished by the manufacturer.

A			B		
t	t^1	$t - t^1$	t	t^1	$t - t^1$
74	56.8	17.2	74.1	58	16.1
74.1	57	17.1	74	58	16.0
73.6	56.7	16.9	73.7	58	15.7

A second series of readings was taken subsequently with both instruments equipped with standard covers on the wet bulb. The results are given below.

A			B		
t	tl	t – tl	t	tl	t – tl
74.8	58.2	16.6	74.8	58.3	16.5
75	57.8	17.2	75.1	57.9	17.2
74.9	57.4	17.5	74.9	57.5	17.4

In correcting self recording hygrometers, the same caution as that indicated for thermographs must be used.

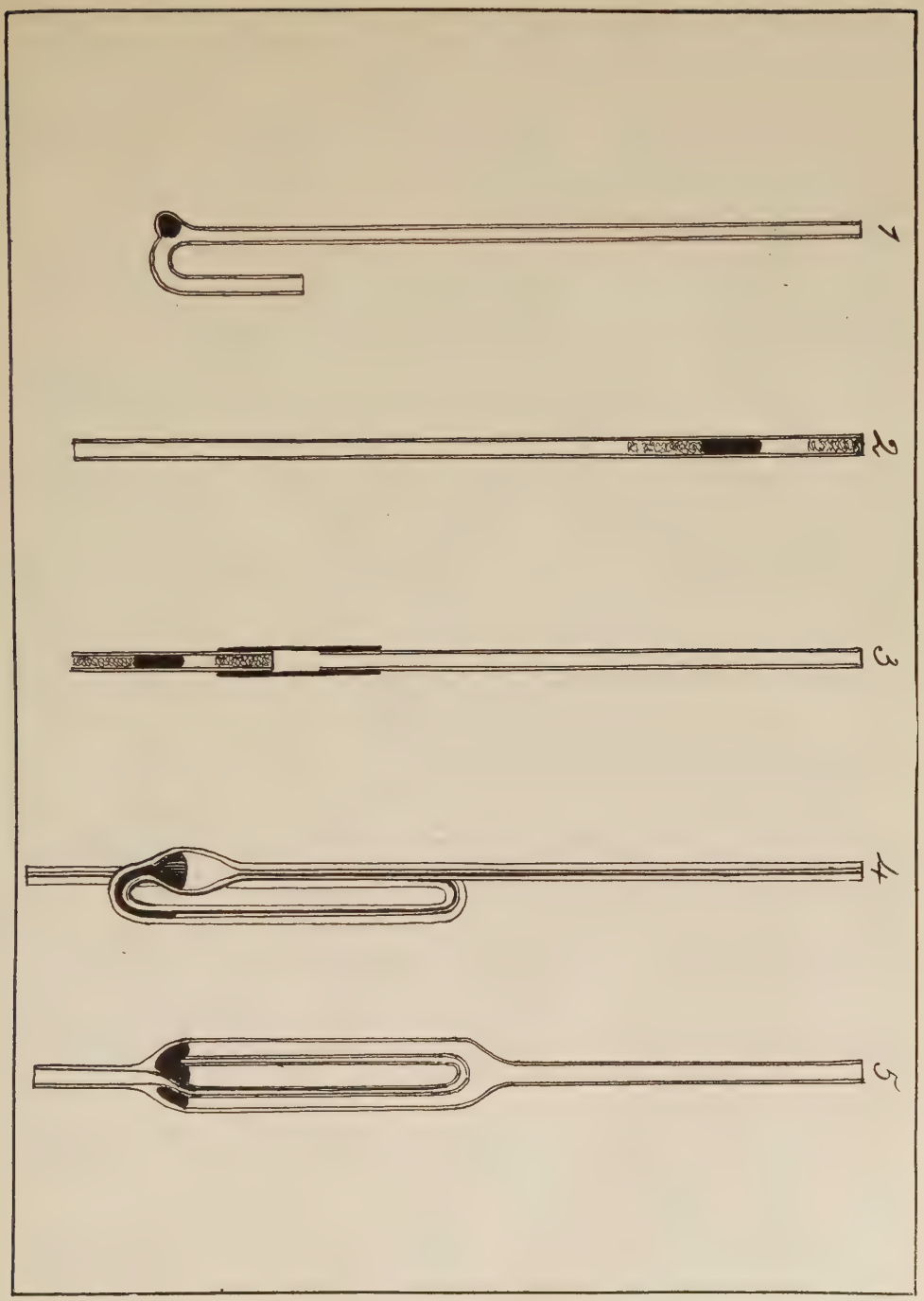
The instrument nowadays most commonly in use for measuring the evaporating power of the air, is the Livingstone porous cup atmometer. Several types of mercury valves for excluding rain from the reservoirs have been designed. The best known are those devised by Graham, by Livingstone and by Wilson.

Graham's mounting (fig. 1) consists of a j-tube with a small bulb on the long stem near the curvature of the tube. The bulb is filled with a drop of mercury of such size as to be held up in the bulb by the upward suction. When a down-pressure occurs the mercury is forced into the bent part of the tube and acts as a counterweight, thus preventing the in-flow of water from the top.

In the rain valve devised by Livingstone (fig. 2) a plug of glass wool is introduced into the feed tube, about 1 cm. of mercury is dropped into the tube and a second plug of glass wool is put into the tube at a short distance above the mercury. Water drawn upward passes by the mercury, whilst downward pressure flattens the mercury against the walls of the tube and prevents the in-flow of the water. This mounting can be put either in the top of the feed tube or at the bottom of it. In the latter case it is advantageous to construct the valve with a separate short tube which may then be joined to the main tube by means of a rubber connection. The latter method facilitates the renewal of valves whenever this may be necessary (fig. 3).

The valve described by Wilson (1930) is an adaptation of the valve used in the Shive atmometer mounting. The feed tube is made of capillary tubing into which a small chamber is blown which contains the mercury. This valve is very satisfactory and its operation can be readily understood by a study of fig. 4.

Lately we made some experiments with a different type of valve, which is somewhat more difficult to construct but is more easily manipulated than the Wilson valve. It is shown in fig. 5. The lower part of the feed tube communicates with the large water chamber by means of a bent arm, the end of which is immersed in the mercury at the bottom of the water chamber. After a sufficient


1
2
3
4
5

amount of mercury has been poured into this chamber to cover the tip of the bent arm, the entire mounting is filled with water by applying gentle suction at the upper end of the feed tube. The latter is then joined to the porous cup in the usual manner. The entire operation is very simple. The principle is the same as that of the Wilson valve. During upward suction the water passes through the mercury, any downward pressure forces the mercury upward into the narrow tube and prevents any back flow. This valve is capable of withstanding considerable pressure.

For reasons mentioned in an earlier part of this paper little need be said here about the methods of measuring light. The reader who wishes to inform himself on this subject is referred to the writings of Zon and Graves (1911), Klugh (1925, 1927), Grasovsky (1929), Atkins and Poole (1929).

A factor of paramount importance in the study of forest insects, is wind. Possibly the most useful instrument for measuring average velocities is the Robinson anemometer. This instrument may be equipped with an electric buzzer by means of which readings may be obtained at any time. For measuring differences in velocity at various points or in various strata, a small portable anemometer is indispensible.

Precipitation has been found to be heavier over wooded areas than over open fields, yet the amount of rain reaching the ground is roughly less than $\frac{2}{3}$ under deciduous trees and more than $\frac{3}{4}$ under conifers. Specially constructed, large gauges equipped with collars for collecting the water running down the tree trunks are sometimes used for studying precipitation under the forest cover. The experiments of Phillips (1928) seem to show that there may be a certain amount of rainfall under the forest cover during misty weather when no rain is registered in adjacent open fields.

The humidity of the duff or litter can be measured in different ways. For top duff in coniferous stands a specially constructed hygrometer has been devised. A description of this instrument is given by Gisborne (1928). Another method of measuring the absolute humidity of the duff is described as follows by Nichols (1928) in his report on Meteorological and Forest Fire hazard conditions in the province of Quebec: "The apparatus consisted of a wire letter-tray some 18″ x 12″ by a few inches in height, obtainable at any office supply store for thirty cents. The sides of this basket spread outward slightly, a useful feature. A piece of muslin was placed over the bottom and wires arranged so that the basket could be easily lifted vertically. A piece of the forest floor was carved out 1″ deep, and of area exactly the same in size as the bottom of the basket, lifted and deposited in the bottom of the basket without any mutilation. The basket was then put into the shallow hole left in the ground, which it fitted exactly. This arrangement therefore allowed for weight determination to be made at will with a spring balance and which would show the change of moisture conditions in this piece of duff. This change would be almost exactly the same as that occurring in similarly located duff round about... In order to make

a weight determination, a spring balance reading to 2,000 grams was used and the basket was lifted clear of the hole by its wire supports suspended over the hook of the balance and a reading taken to the nearest 5 grams and the basket immediately replaced in its position in the ground... In the experiments attempt ed the percentage of error in weighing the basket was not more than 2%."

In hardwood stands we have found it preferable to collect samples in tightly closed cans and after weighing these, to dry them immediately in an oven to ascertain their dry weight. The results can only be considered as approximations.

In the account of the different methods given above, any mention of the purpose of these measurements or their relation to insect life has been omitted, since this would involve a lenghtly discussion outside of the scope of the present brief discussion.

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AN INVESTIGATION OF MONOCHAMUS BEETLES AND THEIR CONTROL

By M. B. Dunn, Assistant Entomologist, Division of Forest Insects, Entomological Branch, Ottawa.

The fires which unfortunately occur in sections of Canadian forests annually are closely followed by various fungi and boring insects. These secondary enemies, though their destructive work is less spectacular than that of fire, nevertheless cause very extensive damage, for they soon render almost worthless timber which otherwise would have remained sound for years.

Among the most destructive of these secondary enemies are the sawyer beetles. They are of two species, the small black beetle, *Monochamus scutellatus*, Say, and its larger grey relative, *Monochamus notatus*, Drury. The black beetle is an insect measuring from ⅝ to 1 ⅛ inches in length, shining black in color, often mottled with grey and white. The grey beetle is considerably larger, measuring from 1 to 1½ inches in length. It is greyish in color, and the antennae are very long, those of the male sometimes measuring three inches. Both these insects are abundant in nearly all parts of Eastern Canada and their appearance is familiar to nearly everyone working in the woods or about lumber yards.

The adult beetles appear in late June or early July and attack pine, spruce and balsam which have been recently fire-killed or are just succumbing as a result of the work of defoliating insects such as the spruce budworm. Logs cut during fall and winter, which for any reason are not hauled and are left in the woods throughout the succeeding summer are also very likely to be seriously injured by these beetles. They will not attack peeled logs or sawn lumber, except when the latter has bark remaining on the edges. They are often numerous about lumber yards, probably attracted thereto by the odor of the newly-cut spruce and pine.

The female beetles lay white, oval eggs about ⅛ inch long in niches which they cut in the bark with their powerful mandibles. In a few days white, legless grubs hatch from these eggs and bore through the inner bark to the surface of the wood where they feed for several weeks, making shallow spreading excavations about ⅛ inch deep. About Aug. 1st the larvae begin to bore below the surface and by Oct. 1st have cut tunnels deep into the wood. In the inner end of these tunnels they hibernate. Lumber sawn from such logs exhibits numerous, large, unsightly holes, which greatly depreciate its value.

Extensive stands of virgin timber which have been fire-swept apparently attract the sawyer beetles from a considerable distance around and the attack in such stands is usually very heavy. In May, 1923, a terrible forest fire swept across more than 50,000 acres in the Kipawa district of Western Quebec, an area largely forested with virgin red and white pine. The sawyer-beetles came to the scene of this fire in millions. The writer examined hundreds of trees from

the outer edge of the burn to a point near its centre and found that practically every tree had been heavily attacked. Trees more than two miles within the burn had quite as many tunnels as those near its edge, showing that at least some of the beetles must have flown a considerable distance to make such a thorough job of the attack.

As previously stated, lumber sawn from logs in which the larvae of Monochamus beetles have completed their growth, invariably has many large holes which have a detrimental effect upon its value. Some time ago the writer visited a number of the larger mills operating in the province of New Brunswick with a view to ascertaining how lumber injured by Monochamus beetles was graded and sold. It was found that the lumbermen throughout the province were by no means unanimous in their estimate of the value of such lumber. As a general rule, however, the larger operators were of the opinion that such lumber can be sold only as the lowest grade material, while the smaller operators are able to place a considerable portion in the next higher grade. This difference of opinion is probably due to the fact that the markets of the larger and smaller operators are not identical. The larger companies dispose of their stock exclusively by export to Gt. Britain, Australia, the United States and the larger Canadian cities, where it commands the highest market price and must be of exceptional quality. On the other hand, the smaller operators dispose of a large part of their stock in the local market and to smaller buyers, who are not so particular as to the exact quality of the material, if the price is not too high. On the whole, it was found that lumber showing worm holes, even though otherwise sound, suffered a serious depreciation in value.

There are several methods of procedure which are of value in the prevention of injury to timber by these insects. The more important of these are briefly discussed in the following paragraphs.

1. Areas which have been fire-swept in May or early June, if contiguous to lakes or rivers, should be logged, if possible, immediately after the fire and the logs placed in water sufficiently deep to float them. The beetles will usually begin their attack upon the burned timber in late June, but the larvae or borers will construct few tunnels of a depth sufficient to produce serious injury to the timber prior to August. Thus there is a period of approximately two months, subsequent to the average spring fire, available for logging operations, before the timber begins to show extensive borer damage. The immersion of the logs will kill practically all the larvae within a few days. This procedure was adopted by a lumber company operating in Algonquin Park following a June fire in that section, with the result that an extensive stand of unusually large and sound white pine was salvaged without appreciable borer injury.

2. Areas which have been burned in early spring and which are not contiguous to lakes or rivers should be cut over and the logs skidded as soon as possible following the fire. The beetle attack will be concentrated to a considerable extent upon the upper tiers of logs in the skidways and the injury to the remaining logs

will be light. Cutting upon areas of this nature can be continued only until the adult beetles begin egg-laying, since skidding the logs, once they are infested, will not prevent development of the borers.

3. On areas which are burned over after Aug. 1st, the timber should be cut during the following winter. This will forestall the greatest injury which would take place the next summer.

4. Skidways of logs left in the bush through the summer are usually so far from lakes or rivers as to make it impossible to get them into water. Where watering is impossible, an effective method of procedure is to cover the skidways thickly and evenly with balsam brush. On the tops of the skidways the brush should have a uniform depth of at least 18 inches, and no areas, however small, should be left uncovered or thinly covered. To protect the ends of the skidways, birch saplings, with the limbs trimmed down to 18 inches in length, should be leaned against the skidway and the brush shingled thickly on these saplings. Due to the amount of labor involved, this method of protection is often quite expensive, the average cost being around 15 cents per log.

5. A new but promising method for the prevention of borer injury is the application to the skidways of lime sulphur dust as a repellant of the adult beetle. Extensive experiments in the use of this material were carried out by the Forest Insect Division of the Entomological Branch during the summers of 1928 and 1929. The results obtained were very encouraging. On skidways treated with the dust the injury was less than 1% of the injury sustained by the undusted skidways.

The dust was transported by pack horse or jumper from the end of the waggon road to the location of the skidways and applied to the latter by means of a portable hand duster. A uniform coating of dust was applied to the top of the skidways and the material also shot between the logs at the end of the skidways. It was found necessary to dampen the skidways well in order to secure a good adhesion of the dust. Three men with a horse and one duster dusted from 500 to 1,000 logs per day, depending upon the size of the skidways and their distance from each other. The cost of the operation, including the price of the dust and the expenses connected with its application, was ascertained to be slightly less than 10 cents per log.

This method of control has not yet been given sufficient trial to warrant its unqualified endorsement, but the results of the past summer's experiments, in the course of which several thousand logs were treated, indicate the desirability of further work in this direction.

The composition of the lime sulphur dust used is as follows:—

Active ingredients, 85% as follows:—

Calcium polysulphide	70%
" thiosulphate	5%
Sulphur	10%
Inert ingredients	15%

THE HEMLOCK LOOPER INFESTING BALSAM IN THE PROVINCE OF QUEBEC

By E. B. Watson, Entomological Branch, Ottawa.

Within the last twenty years, the ravages of the spruce budworm have resulted in the destruction of an enormous amount of pulpwood in the province of Quebec from Lake St. John to Temiskaming. With the passing of this outbreak, about 1921 or 1922, the people of Quebec were beginning to hope that their pulpwood resources were more or less free from this great insect scourge. In the summer of 1928, however, the Entomological Branch were informed of an outbreak on the North Shore of the St. Lawrence river about 150 miles below Tadoussac; this district, which supports some of the finest pulpwood stands in the province, escaped the budworm attack which occurred in the Saguenay district in 1910 and 1911, and from the meagre information that was offered, it looked as though another budworm outbreak had developed. A hurried visit to the scene of the infestation showed that the pest was the hemlock looper, an insect known for some years to be a destructive enemy of balsam fir in Newfoundland and also an important pest on hemlock in Ontario and British Columbia.

The outbreak of the hemlock looper on the North Shore was the first record of the insect affecting balsam in Canada, and its presence in such valuable stands of pulpwood was quite naturally viewed with considerable alarm and anxiety. The outbreak had developed with extraordinary rapidity; almost without warning, swarms of caterpillars appeared on the trees in midsummer, stripping some of them completely. In September the moths were in myriads; they were to be seen resting on almost every tree-trunk in the forest, and the lakes and rivers were covered with their bodies.

The insects must have been present in ever-increasing numbers for some years but apparently no one had noticed anything unusual in 1927 or the preceding years; no caterpillars were observed, nor was there any flight of moths on a large scale to be seen in the fall. This is corroborated by the fact that there was no appreciable reduction in the growth of the balsam which might indicate defoliation in 1927 or earlier. The spruce appear to have been unaffected by the insect with the exception of small trees growing in heavily infested stands of balsam.

The character of an outbreak of the hemlock looper differs in many respects from that of a spruce budworm infestation; in the latter, the balsam over the whole area are generally infested to some extent. In the case of the hemlock looper, the infested areas were very patchy and sharply defined. Stands of

balsam in one locality may be totally defoliated while adjacent stands of the same type less than a quarter mile distant may be entirely free from injury.

Under these circumstances, it is difficult to give an accurate estimate of the area actually infested and the coresponding loss of merchantable timber.

The percentage of trees killed by the hemlock looper may vary from nil to one hundred per cent, reproduction included. The following figures with reference to the average condition in one of the infested areas may be of some interest:

Dead	Injured (probably die)	Injured (probably live)	Uninjured
8.0%	23.7%	52.6%	15.7%

As a result of extensive aerial and ground surveys, it is estimated that about 90,000 acres are involved. This does not represent one solid block of infested timber, but the sum total of all the defoliated and partially defoliated areas on the North Shore; this acreage also includes small, uninfested patches and spruce type in areas which, on the whole are classified as being infested. About ninety miles separate the eastern and western points of infestation.

The financial loss sustained in the outbreak cannot be determined with any degree of accuracy until the entire infested area has been cruised. About one million cords are probably affected; much of the dead timber will be salvaged within the next few years and a considerable proportion of the injured trees can be expected to recover. To offset this, however, the reproduction has been killed outright or severely injured in many localities, so that the forest will require a longer time to mature before the new crop reaches merchantable size.

Balsam that were completely defoliated in 1928, the first year of heavy feeding, commenced to die during the following winter. Generally speaking, the injury is more severe and defoliation more thorough than that caused by the spruce budworm, as it is unusual to find balsam killed in one year by that insect. The feeding of the hemlock looper not only resulted in the death of the merchantable timber, but also killed off the reproduction in many districts.

During the past summer, the degree of injury was considerably less than that sustained in 1928. Although enormous numbers of caterpillars hatched in June, they failed to reach maturity in most of the infested areas, with the result that the moth flight in the fall was almost non-existant; the exact cause of the decline is not apparent; it can probably be attributed to unfavourable weather conditions as natural enemies in the form of parasites and predators were not in evidence to any appreciable extent.

It is practically useless to attempt to forecast the activities of the hemlock looper for the ensuing year; it may disappear entirely or on the other hand the outbreak may continue with renewed vigour. One ray of hope lies in the fact that the North Shore outbreak is the first record of the insect affecting balsam in Canada; since the hemlock looper is native to North America, there is every reason to believe that epidemics have occurred in the past but have subsided as rapidly as they developed, with the result that they have been overlooked or disregarded. Possibly the conditions favouring these outbreaks occur only at infrequent intervals, so that the insect may not be heard of again in epidemic form for a number of years.

The fact remains, however, that the hemlock looper has proved itself to be a serious and destructive pest in the province and will always remain a potential source of danger to stands of balsam fir.

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